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MODERN OPERATIVE SURGERY

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OPERATIVE SURGERY

THIRD EDITION

EDITED BY

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(By courtesy of Sir Harold Stiles, Mr. Henry Wade and the Edinburgh Medical Journal.)

EDITORIAL NOTE

The new contributors to the third edition of the completed work are A. J. Gardham, V. E. Negus, L. Carnac Rivett, Lambert Rogers, R. Ogier Ward and W. E. M. Wardill.

CHAPTER XXIII

OPERATIONS FOR HERNIA

By G. GREY TURNER

History.—Operation for the radical cure of hernia is one of the oldest of surgical procedures, and many methods have been employed. Those known by the names of their authors, Wood, Czerny, Annandale, Mitchell Banks, Ball, Macewen, and Kocher, to mention only a few, described during the period 1876–90, have now mainly an historical interest. Incidentally, it is important to remember that a great deal of the detail of modern wound treatment has been evolved in connection with the radical cure of hernia. The greatest advance in the operation resulted from Bassini's work, first described in 1888. The fundamental steps consisted in dividing the fibres of the aponeurosis of the external oblique sufficiently to expose the whole of the inguinal canal, separating the sac from the cord to the highest possible point, transfixing and tying it at the neck, removing the sac, transplanting the cord, and suturing the conjoined tendon behind the cord to the inner surface of Poupart's ligament. This soon became the standard operation, and forms the basis of most methods at present in use. Modifications have arisen from time to time, the most important being the Wölfler operation, similar in all respects to Bassini's, except that the cord is not transplanted, and resembling the Bevan operation, which has a particular value in the cure of congenital hernia in children with incomplete descent of the testis.

Halsted, in 1890, modified the Bassini operation by dividing, not only the external oblique, but also the internal oblique and transversus muscles and the transversalis fascia to a point 1 in. external to the internal ring, forming a new internal ring external to the original one, transplanting the cord, which had been stripped of most of its vessels, and uniting all the divided muscular and aponeurotic structures behind the cord, which thus came to lie directly under the skin. Lockwood displaced the neck of the sac, after transfixion and ligation, high up under the transversalis muscle by passing the long ends of the ligature through the transversalis and internal oblique muscle from within outwards, and tying the ends together on the surface of the internal oblique under cover of the aponeurosis of the external oblique. Polya, in 1905,* realizing that recurrence takes place, if at all, at one of two points—(*a*) at the lower angle of the canal or (*b*) at the entrance of the cord to the canal—adopted the Halsted method of resecting the redundant vessels of the cord, and displacing the latter. To strengthen the weak spot at the lower angle of the canal he opened the sheath of the rectus for a distance of some two inches from its pubic attachment, mobilized the muscle, and sutured it to Poupart's ligament.

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* *Centralbl. f. Chir.*, 1905, No. 9, xxxii, 210.

Thus, during the last half century the root idea of Bassini's operation has been accepted, and such variations as have been suggested have had for their object the strengthening of degenerated structures. Bassini's operation is admittedly adequate where muscular development is satisfactory, e.g. in the ordinary oblique inguinal hernia of congenital type occurring in children or healthy young adults. When the hernia is associated with or has resulted from weakness or degeneration of the abdominal muscles, particularly of the conjoined tendon, additional steps, such as the overlapping of the external oblique aponeurosis, the use of the rectus muscle or sheath or the employment of fascial sutures are indicated. Especially is this the case in direct inguinal hernia.

From time to time surgeons have supplemented their efforts at radical cure by the use of metallic suture material. In 1909 Lawrie McGavin published an account of silver wire filigrees buried in the hernial sites, where they are intended to remain, and after incorporation with the tissues to act as barriers against recurrence. The lapse of time is showing that this plan has attained more success than has been acknowledged. In their search for some yet better method Gallie and Le Mesurier experimented with strips of fascia lata used as sutures. This was soon recognized as a new principle, for it was proved that the strips become incorporated with the tissues and survive as a permanent addition to the architecture of the areas in which they are employed. Their first paper was published in 1924 and since that time the method has been subjected to an extensive world-wide trial and is recognized as a great addition to the solution of the hernia problem.

During the last few years there has also been a revival of interest in the old method of injection for the cure of hernia and this has been conscientiously subjected to further trial, notably by Delisle Gray in this country.

In every decade there are surgeons who become dissatisfied with the results of operations designed for the radical cure. The winter of their discontent does nothing but good, for it is well that the attention of the profession should be focused on those procedures which, lacking the elements of novelty, are too often treated with dangerous complacency. But all who have looked into this question with unbiased minds have had to admit that the degree of non-success which they deplore is often due to causes which are preventable. Too often the operation for the radical cure of hernia is regarded as trivial or unimportant, and left to enthusiastic but inexperienced juniors, who have often but a superficial knowledge of the anatomy of the parts concerned and a poor understanding of the essentials necessary for repair. Even with ampler knowledge they often lack the technical skill which should be brought to every detail of this most important operation.

The history of the operative management of hernia throughout the last half-century has emphasized the fact that all hernias are not the same and that individual consideration is necessary in the management of a condition which is often of great economic importance.

Methods available.—There are only two methods which hold out a prospect of permanent cure in hernia—open operation and injection. The latter only requires mention in a work on operative surgery. It has the one outstanding advantage that it is ambulatory and, in fact, many patients can continue to follow their occupation while undergoing treatment. But it is limited to inguinal hernias that are completely reducible and can be efficiently controlled by truss. From 8 to 12 injections are required at weekly intervals. Complications are few, but local inflammations and even peritonitis have occurred. The recurrence rate is stated to be about 8 per cent. No large series of cases appears to have been followed up over a period of several years.

Principles of operation.—The principles underlying the radical cure of all hernias are the same, namely, the complete isolation and removal of the sac, and the restoration and strengthening of that part of the abdominal wall through which the hernia has protruded. To attain these objects very numerous plans have been adopted and modifications are constantly being introduced, but the prospect of their success depends on the observance of these principles.

Indications for the radical cure of hernia.—In these days there are very few cases of hernia that need be refused operation. Apart from the inconvenience which hernia causes, the real danger is strangulation, which still claims a mortality of about 20 per cent., whereas the mortality of operations for radical cure is considerably less than 1 per cent. This alone is a very cogent argument for operation. An attack of strangulation, even if the patient recovers without surgical interference, is always an indication for subsequent operation, for this complication is very apt to recur. With the methods of treatment now available, diabetes, or renal and cardiac disease are no longer absolute contra-indications, though they each require special measures to render operation justifiable. The greatest barriers to success are ruptures of so great a size that the contents cannot be comfortably returned to the abdomen; persistent and incurable cough; or advancing obesity which cannot be controlled by diet.

In old-standing cases it is necessary to be sure that the hernia is not just a cloak for some other disease which is the cause of symptoms the patient unwittingly attributes to his obvious encumbrance. For instance, fat women with umbilical hernia often suffer from gall-stones but invariably attribute their biliary attacks to the rupture. Similarly, elderly men who have endured the inconvenience of a hernia for years will often begin to think of a radical cure when symptoms due to enlarged prostate become troublesome.

The object of intervention.—In children and healthy young adults operation can be undertaken in the confident expectation that the hernia will be permanently cured. In elderly and less robust members of the community and in those suffering from very large hernias operation may still be the best treatment, not only to remove the dangerous risk of strangulation, but to add to comfort and to promote well-being, but it cannot be undertaken with the same prospect of lasting cure. These patients should be warned that if signs of recurrence become manifest they should report for advice. Recurrence in the young adult usually justifies further operation. In the more elderly it may be wiser to fall back on a properly fitting and well applied truss. If the apparatus is used when the relapse first appears it will prevent deterioration of the condition and may enable the patients to fulfil those activities for which they are otherwise fitted. In this way operation may be the means of exchanging a truly heavy burden for a manageable inconvenience.

The surgeon should hesitate to make rash promises about the prospects of radical cure. The advantages of the operation have proved so great that its reputation can sustain the opprobrium which naturally attaches to an occasional recurrence.

Suture material for the operation.—Most surgeons now use chromicized catgut, No. 3 being suitable for the deep sutures and No. 1 for the other parts of the operation. The Halsted school still use very fine black silk, and there are an increasing number who follow the Kocher technique and use thin Chinese twist silk. But surgical memories are short and it is apt to be forgotten that every now and again troublesome sinuses follow the use of unabsorbable sutures. Whatever material is used, it must be realized that the final success of the operation does not depend on the suture material but on the power of the tissues to unite. To give them the best chance, accurate and close apposition without tension is essential.

The use of living sutures introduced almost a new principle in the treatment of hernia.* The method was very carefully worked out by Gallie and his co-workers in Toronto. Their experiments showed that the lateral approximation of muscles to fibrous structures results in only a feeble union by scar tissue. They found that living autogenous sutures of fascia or tendon survived and became permanently incorporated with the tissues. They used this method in certain types of hernia, especially the direct, umbilical and ventral hernias and recurrent cases. The sutures are cut from the fascia lata or from the external oblique bordering the inguinal canal. When the fascia of the thigh is employed it is exposed by a long incision on the outer side. The strips are about 10 in. long and one quarter of an inch wide and in an ordinary case two, or at most three, suffice. The gap left in the fascia is closed whenever possible, but little inconvenience has followed when this has not been done, provided, of course, that the skin incision is carefully sutured. Occasionally a large bulging hernia of the vastus externus has developed and caused alarm. To avoid this sequel when the fascial wound cannot be closed, the edges should be drawn as near together as can be accomplished without tension and then fixed to the underlying muscle by a few points of suture. Several special instruments have been devised for cutting the strips subcutaneously and some patterns are said to be satisfactory. The strips must be fixed by catgut or silk through the large eye of a round needle and the extremity should be tied with a ligature to prevent fraying. It is more convenient to thread the strips before the opposite end is cut away from the thigh. It is convenient to have one worker cutting the strips from the thigh opposite to the hernia and handing them ready-threaded to the operator. These sutures are sometimes used in place of catgut or other material for approximation of the muscles, in routine operations for hernia, or they may be employed to supplement ordinary sutures whether of catgut or silk. Where the edges cannot be approximated without great tension, or where there

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* Gallie and Le Mesurier, *Brit. Journ. Surg.*, 1924, xii, 289.

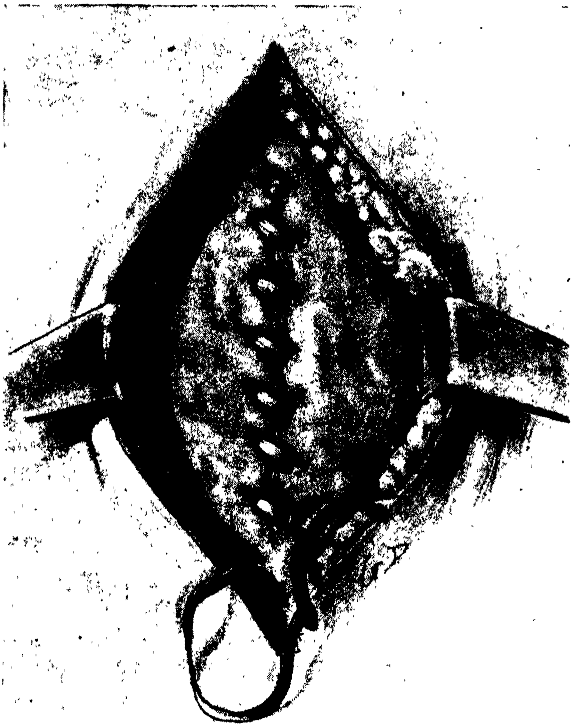

Fig. 501.—The repair of ventral hernia with sutures of fascia lata. The first suture approximates the recti in their sheaths.

This and the following figure are redrawn by permission of Prof. Gallie from his article in the *British Journal of Surgery*, 1924, xii, No. 46, 289.

are apertures in muscles or fibrous structures, as in some cases of direct or ventral hernia, the fascial strips are used to make a sort of latticework between the tissues and across the apertures, so that the latter are protected by a mesh of interwoven and interlaced strips, as shown in the diagrams copied from Gallie's original article. (Figs. 501, 502.) Running sutures are used and some form of lock-stitch is employed every third or fourth bite, because of the slippery material. The final stitch must be securely fixed by an independent suture ligature of catgut. Similar care must be taken to attach one suture to the next if a particularly long lace is required for darning. In the hands of the originators, and indeed in others who have reported cases,* the results have been very satisfactory. But it must be stated emphatically that fascial sutures are only adjuncts in the radical cure and do not compensate for want of care in carrying out every detail of the operation. In 1930, Gallie and Le Mesurier† reported a series of nearly 200 cases with only 6 known failures. Many of the cases supplied the severest possible test, for among the first 50 there were soldiers suffering from recurrence after one, two and sometimes three operative

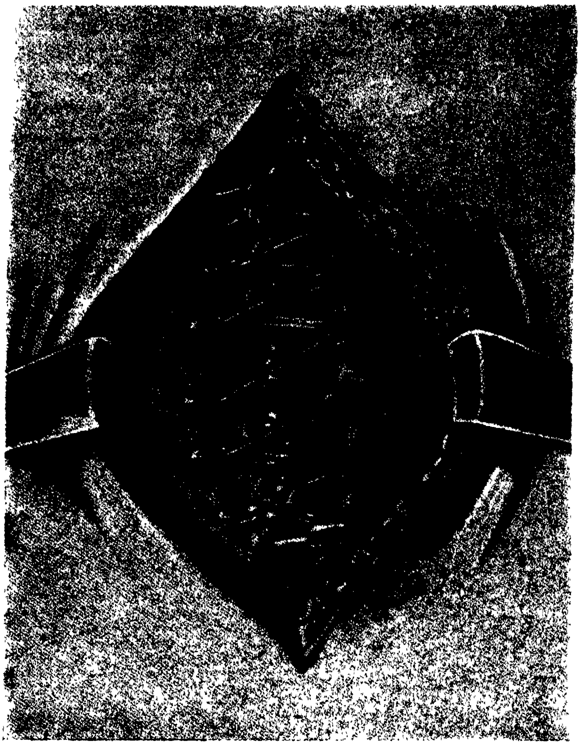

Fig. 502.—The second layer of sutures has been inserted and fixed.

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* Keynes, *Brit. Med. Journ.*, Jan. 25, 1929, i, 44.
† *Journ. Canad. Med. Assoc.*, xxiii, 165.

attempts at radical cure. There were also ventral and inguinal hernias so enormous as to be almost unbelievable, and several were in patients suffering from chronic bronchitis and asthma, in whom the hernia had recurred after the operation because of uncontrollable cough. This résumé indicates the sort of case in which these sutures can be most usefully employed. Though they have largely superseded the use of wire filigree, the latter has still a field of usefulness.

The Filigree double method.—On general principles it is unwise to bury unabsorbable foreign bodies in the tissues. Nonetheless, silver wire filigrees (size 28 S.W.G.) have been used to reinforce the hernial region and have seldom caused trouble. In the last edition of this work it was stated that the fascial suture method had entirely superseded the filigree, but time has shown that the wire support may occasionally be used with success when the fascial suture has failed. Cases have now been watched over a period of many years and the results for radical cure have been very satisfactory. In only very few instances has the filigree worked loose or had to be removed. At the Dreadnought Hospital (Greenwich) the method has been continuously in use since its introduction by Lawrie McGavin thirty-five years ago.[*]

Technique.—The operation should be carried out under spinal anæsthesia, as perfect relaxation and abdominal quietude during the immediate post-operative period are essential. Very strict asepsis must be observed. The canal is freely exposed and the sac dealt with as in other types of radical cure. A bed must then be prepared for the filigree over the structures forming the posterior wall of the canal. If the transversalis fascia is intact it forms the best foundation, but any rents in it should be repaired and loose tissue in the neighbourhood drawn over it. The lower arched fibres of the internal oblique and the outer border of the rectus are defined, so that the edge of the filigree can be slipped beneath them. A filigree must be selected which will cover the whole of the posterior surface of the canal and will lie flat without any tilting of its edges. It should fit so snugly that fixation by suture is unnecessary. The oblique muscle and sometimes the rectus are then sutured to Poupart's ligament behind the cord, and this sufficiently holds the filigree in position. After replacing the slack of the cord in the scrotum, the superficial filigree is placed over the sutured muscles so that its lower end extends well below the deep filigree, i.e. further towards the pubes. This filigree is kept in position by suturing the external oblique over it, using the overlapping method when possible. Much care is taken to approximate both the deep fascia and the skin. The patient must lie very quietly for the first few days. Occasionally a collection of serum forms at the outer end of the incision, but it can be safely evacuated and will not delay healing for long. Three weeks should be spent in bed and heavy work should not be resumed sooner than four months after operation.[†]

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[*] Percival P. Cole, *Brit. Journ. Surg.* Oct., 1941, xxix, No. 114, 168.

[†] For details see *Brit. Med. Journ.*, Aug. 14, 1909, ii, 357 ; *Lancet*, Feb. 23, 1924, i, 385, and May 22, 1926, i, 974 ; and also above reference.

Preparation for operation.—There can be no excuse for operating on hernia without proper examination and necessary preparation for, apart from strangulation, there ought to be no urgency. The causes of even slight cough should be sought and treated, for this may make a great difference not only in convalescence but to ultimate success. Abdominal distension must also be overcome. In very large hernias, the patient should be kept in bed for a few days with the head low, and high blocks under the foot end. This not only helps to reduce the size but gets the patient accustomed to lying on the back and tolerating the addition of all or part of the hernial contents to the abdomen.

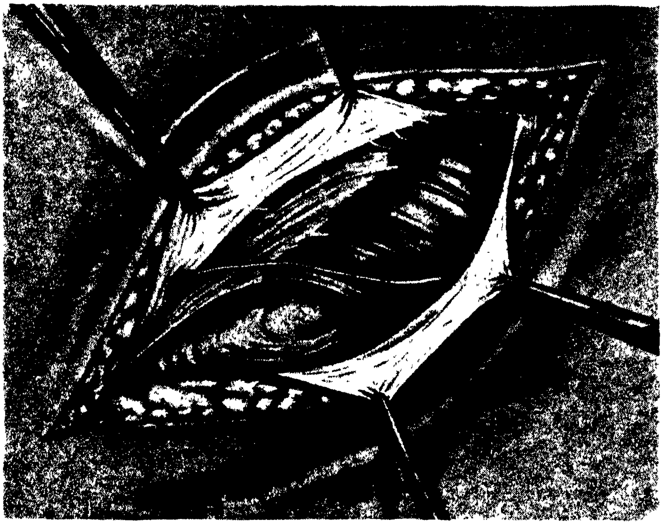
Special care should be taken in the skin preparation, as the region of the groin is apt to harbour dirt and infection, and the skin is often moist and may be affected by intertrigo. The same remarks apply to umbilical or ventral hernia in which folds of skin and deep sulci are concerned. In inguinal and femoral hernia, it is wise to indicate the side to be operated upon by a cross or other mark on the thigh or elsewhere, to prevent the mistake of operating on the wrong side.

Anæsthesia.—For routine work, and in most cases, careful general anæsthesia is efficient and convenient, but there are many cases in which local anæsthesia is indicated, and especially those complicated by strangulation. There is no hernia, however large, which cannot be operated upon under local infiltration combined with regional anæsthesia, though it requires patience and care and consumes a good deal of time. The operation takes longer, and those who have been operated upon by both general and local methods sometimes complain of the after-pain of the latter. Spinal anæsthesia is equally efficacious but has its own special risks.

OBLIQUE INGUINAL HERNIA

Bassini's operation.—This operation has yielded such good results in the hands of so many surgeons the world over that it is properly regarded as the standard method to be employed unless there are some special reasons for adopting some other plan. The steps of this operation may be thus epitomized: (1) exposure of the whole canal by an adequate incision through skin and subcutaneous tissues; (2) division of the external oblique muscle from the external ring to a point well above the level of the internal ring; (3) identification and opening of the sac with treatment of contents; (4) separation and isolation of the sac to the highest possible point, which ought to be well above its neck; (5) ligature and removal of the sac; (6) the formation or reconstruction of the posterior wall of the canal by suture of the lower edge of the internal oblique and transversalis muscles and conjoined tendon to the inguinal (Poupart's) ligament, behind the cord; (7) repair of the external oblique muscle, the margins being overlapped if the structure is at all lax; (8) careful suture of the skin together with the whole depth of subcutaneous fat.

Technique.—An incision is made parallel with Poupart's ligament, and ½ in. above it, from a point just above the spine of the pubis to a point an inch or so external to the middle of Poupart's ligament. In very stout subjects the incision must be much longer, depending upon the amount of subcutaneous fat. It is carried throughout its whole length down to the aponeurosis of the external oblique, exposing and dividing at right angles the superficial external pubic and superficial epigastric vessels, which must be secured. On exposure of the aponeurosis, its fibres are seen to be parallel with the incision, separating below and medially to form the external ring. The aponeurosis is divided with a sharp scalpel in the line of its fibres, starting from the external ring. The two flaps are dissected back, the upper one so as to expose the conjoined tendon for a depth of ¾ in., the lower to expose the upper grooved surface of Poupart's ligament. In reflecting the upper flap, care must be taken to recognize and safeguard the ilio-hypogastric nerve, which runs on the outer surface of the conjoined tendon, parallel with and ½ in. from its free edge. This nerve, if divided or caught in a suture, might give rise to pain during convalescence. The conjoined tendon (internal oblique and transversalis) is now seen arching over the cord from above downwards and inwards. (Fig. 503.) The attachment of the lower fibres of the muscles to Poupart's ligament in the outer part of the incision must be carefully preserved. The ilio-inguinal nerve is defined and safeguarded. The cord and hernial sac are exposed at the inner end of the incision as they pass towards the scrotum. If the sac is occupied, it may form a bulky mass, but if empty and thin it may scarcely add to the size of



Fig, 503.—Radical cure of left inguinal hernia : aponeurosis of external oblique incised, exposing conjoined tendon and ilio-hypogastric nerve.

the cord. The cord, with the sac, is then lifted out of its bed and the position of the vas and the main vessels defined. The sac is now exposed by incising, or separating the coverings with the dissecting forceps. The cremaster muscle varies very much in bulk and strength ; as a rule its fibres can be separated, but they may have to be incised. The sac, having been found, is caught in forceps and the process of separation from the structures of the cord is commenced. This can usually be done easily with dissecting forceps aided by gauze stripping. If the sac is very adherent, it is more easily manipulated if opened and a finger introduced into its interior. If it is very bulky because of its contents, the latter are better returned to the abdomen before further separation is attempted. The contents may be adherent and bands may have to be exposed and divided, care being taken to apply ligatures to any bleeding structure that is to be returned to the abdomen. On the other hand, broad areas of bowel may be adherent to the sac and will have to be very carefully separated with scissors. The contents may be free so far as the body of the sac is concerned but may be adherent all round the neck and cannot be reduced until released. Very firm adhesions of bowel to the fundus of the sac may be dealt with by cutting away a portion of the sac and leaving it attached to the bowel, to be returned to the abdomen with it. After the sac is completely emptied, its separation is continued. If the fundus is very densely adherent to the structures of the cord, it may be cut off and left attached to the latter. This plan was devised by A. E. Barker

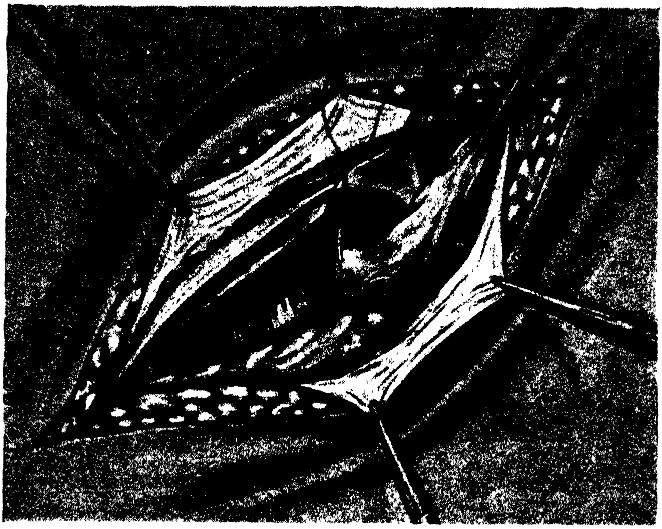


Fig. 504.—Radical cure of left inguinal hernia : sac isolated and transfixed, preparatory to ligature. While this step is being carried out, the sac should be held taut, and the ligature should be placed at the highest possible point. In this figure the sac is not sufficiently on the stretch, and the ligature is not high enough.

and is sometimes advisable as it avoids the hæmorrhagic oozing and the risk of hæmatoma that may follow the separation of a very adherent sac. The fundus having thus been freed, the surgeon takes the sac in his hand and makes strong traction, at the same time using gauze stripping to clear the parts about the neck. In this way it is isolated to the highest possible point. Care must be taken not to injure the deep epigastric artery which is often seen on the inner side of the neck if the separation has been sufficiently thorough. The neck of the sac is transfixed with a ligature of No. 1 chromicized catgut. This is securely tied around one half and then around the whole. The sac is now cut away and, if it has been ligatured sufficiently high up, the stump will retract into the cellular tissue without leaving the funnel-shaped depression which might encourage recurrence. When the neck of the sac is very wide it is difficult to prevent the abdominal contents slipping down while the suture ligature is being passed. This may be overcome by twisting the sac at its neck before applying the ligature. If the neck of the sac is torn during separation or ligature it may be better to catch the edges of the hole in artery forceps, to cut away the remainder of the sac, and then to close the peritoneum by a continuous suture as in laparotomy. Sometimes there is an extension of the sac which passes beneath the epigastric vessels and may be prominent to their inner side (Fig. 505). Such an extension must be removed with the sac as it may otherwise be a cause of recurrence. The sac having been securely dealt with, the next step is to prepare the parts for the insertion of the deep sutures.

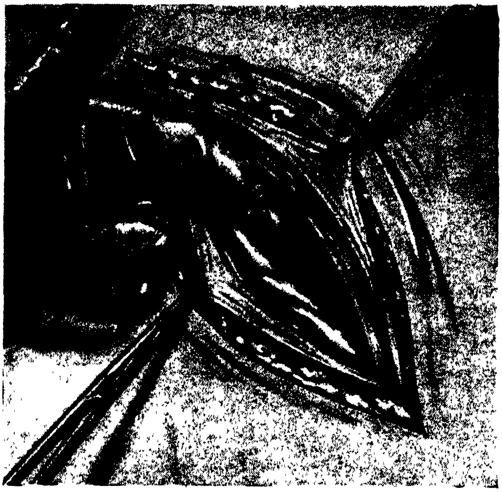


Fig. 505.—Pouching of sac beneath epigastric vessels.

The vas and cord are held out of the way with a retractor or a pair of ring forceps, and the edge of the lower border of the internal oblique, conjoined tendon and Poupart's ligament are systematically cleared

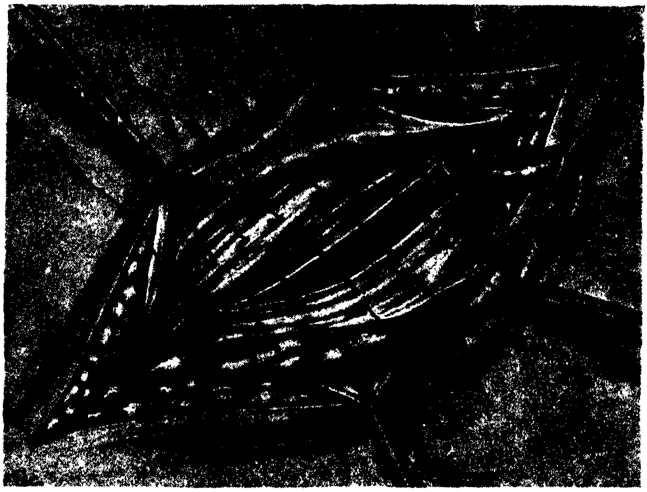


Fig. 506.—Radical cure of inguinal hernia : cord held aside, suture of conjoined tendon to upper surface of Poupart's ligament.

of fat. The internal oblique and conjoined tendon are then sewn down behind the cord to the upper grooved surface of Poupart's ligament by sutures of chromicized catgut No. 3. (Figs. 506 and 507.) The upper suture is applied so as to leave room for the cord to pass without pressure, and the greatest care is taken that the needle, in picking up Poupart's ligament, does not injure the femoral or epigastric vessels or lacerate this rather delicate structure. A half-circle round needle, i.e. not a cutting needle, should be used. The sutures are

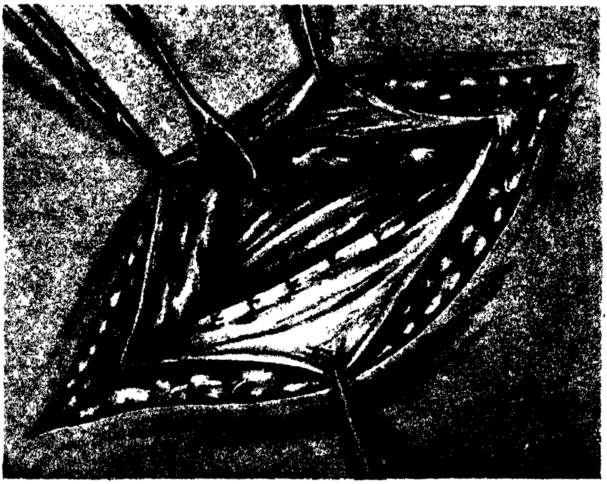


Fig. 507.—Radical cure of inguinal hernia : further stage of the suture shown in Fig. 506.

inserted from above downwards and the first step is to place the tip of the forefinger beneath the edge of the upper border of the canal which, at this point, will be the internal oblique. The point of the needle is inserted half an inch away from the edge of the muscle and is passed completely through the muscle on to the finger, which protects the peritoneum and the epigastric vessels. In this way a workman-like hold of the structure is secured. The ilio-hypogastric nerve must be avoided. The point of the needle is then introduced behind Poupart's ligament and this structure is lifted away from the underlying vessels before the needle actually penetrates. In this way the vessels are kept out of harm's way. The suture at the extreme inner end of the canal is very important as it is at this point that recurrence is most likely to appear. Some surgeons try to include the periosteum of the pubic bone in this stitch. All the sutures should be placed before any are tied but, even so, in bulky patients it may be better to commence placing the sutures at the pubic end and work outwards. It is essential that the suture be placed exactly at right angles through the two structures, so that as little damage as possible may be done, and that the suture be not tied so tightly that the tissue held by it is strangled. All that is required is uniform apposition without tension. Five to eight of these sutures are usually sufficient. When the internal oblique is lax an additional stitch may be placed external to the cord. The cord is allowed to fall back on the sewn-down conjoined tendon, and the aponeurosis of the external oblique is sewn up with interrupted sutures of No. 1 chromic catgut, usually with overlapping. (Fig. 508.) The reconstructed external ring must not be too tight. The wound is closed without drainage after the most careful hæmostasis. It is important that the depths of the subcutaneous

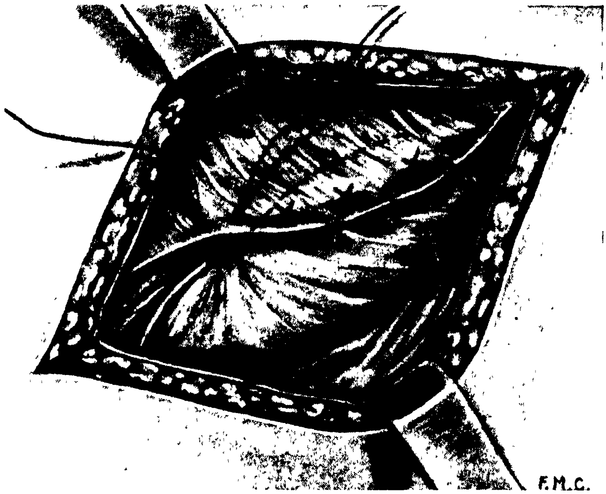


Fig. 508.—Radical cure of inguinal hernia : suture of aponeurosis of external oblique by overlapping.

tissue should be brought into good apposition, and for this purpose three or four of the skin sutures should be carefully passed so as to include its whole thickness. The extreme skin-edges can then be drawn together with fine intermediate sutures. It is especially important that the cord at the inner end of the incision should be protected by subcutaneous fat.

In young healthy subjects this operation, carefully carried out in all its details, probably yields as high a proportion of radical cures as it is possible to obtain. In older subjects or in those with poor muscles, or when the posterior wall of the canal is very wide or the parts do not come into apposition without tension, the results cannot be expected to be as satisfactory and it is this group which accounts for such a proportion of recurrences as to lead some surgeons to discredit the Bassini operation. In these cases catgut sutures may be usefully supplemented by continuous fascial sutures, either cut from the edge of the external oblique or from the fascia lata.

Modifications are all of a minor order, and all of them retain the main principles of exposure of the inguinal canal by dividing the external oblique aponeurosis, the ligature and removal of the sac at the highest possible point, and the reconstruction of the canal by suture of the conjoined tendon to the deep surface of Poupart's ligament. The chief modifications concern displacement of the neck of the sac after ligature, transplantation of the cord, closing the upper end of the canal round the cord, the use of the rectus muscle or sheath to strengthen the lower end of the canal, and overlapping the flaps of external oblique aponeurosis. Barker's modification (leaving the fundus of the sac attached to the cord) has already been mentioned (p. 1052).

Displacement of the neck of the sac.—After the sac has been tied the ends of the ligature may be threaded on a needle and passed through the muscles from within outwards at a point an inch above and external to the ring. The ends of the ligature are then tied on the outer surface of the muscle. In this way the ligatured stump is displaced upwards and outwards.

Removal of the veins of the cord.—To diminish the bulk of the cord some surgeons systematically remove the veins, and this was an essential feature of the original Halsted operation. Atrophy of the testicle not infrequently resulted. The method should not be used unless there is a co-existing varicocele or the veins are particularly bulky. A leash of veins should always be left with the vas.

Transplanting the cord.—It is the general opinion that in operating on infants, and especially on cases of hernia associated with imperfect descent of the testis, the cord should not be transplanted (i.e. placed in front of the sutured muscles) and this is the custom generally with the round ligament in inguinal hernia in women. In all other cases the cord is transplanted by most surgeons.

In the British Isles the original Bassini method of transplanting the cord between the sewn-down internal oblique and the aponeurosis of the external oblique is the rule. Halsted's transplantation between the aponeurosis of the external oblique and the skin is not often done and appears to be of no advantage. When the muscles are very lax the external oblique may be overlapped and fixed by suture. This may be done from above downwards or from below upwards, the cord being left in the Bassini position. (Fig. 508.)

Torek maintains that the sac comes down between the vas and the spermatic vessels which meet at an angle at the internal ring, and to secure radical cure he separates the vas and cord widely and sews the conjoined tendon down to Poupart's ligament between them, making the vessels come through at the upper end of the canal and the vas at the lower. The lower end of the canal is reinforced by suturing the rectus muscle in its sheath to Poupart's ligament.

Philip Turner's[*] operation differs in many respects from Bassini's. Accepting Hamilton Russell's theory[†] that all hernial sacs are congenital, he adopts a method which he states was independently suggested by G. L. Chiene.[‡] His incision is rather higher than Bassini's and, after exposing the external oblique aponeurosis, he identifies the upper margin of the external ring, and incises the aponeurosis in the direction of its fibres, starting a finger-breadth above the centre of Poupart's ligament and terminating ½ in. short of the upper margin of the external ring, thus preserving the intercolumnar fibres. Through this opening the sac is separated from the cord, after retraction of the conjoined tendon upwards and inwards with a blunt hook. The sac is separated at the site of exposure, then the lower end is freed, and finally the upper end. The sac is pulled down so as to expose the neck, which is transfixed, tied with catgut and divided. The ligature is cut short, the stump retracting behind the internal oblique without being secured to the muscle. No attempt is made to suture the conjoined tendon to Poupart's ligament, a step which Turner considers unnecessary unless there is secondary muscular weakness. The incision in the external oblique aponeurosis is closed with a continuous catgut suture, and the incision in the skin is sewn up.

Cecil P. G. Wakeley[§] advises that the fascia transversalis should be sutured to Poupart's ligament, and the lower flap of the external oblique to the transversalis fascia ; the operation is then completed by the suture of the edge of the upper flap of external oblique to the lower flap behind the cord. Because " it is impossible for muscular tissue and tendon to unite " no attempt is made to suture the conjoined tendon to Poupart's ligament.

Dressing and after-treatment.—The dressing should be anchored over the lower end of the incision with a silkworm stitch. Wool and a spica bandage should be applied in all cases, as the patient needs this support during the stage when there may be vomiting and coughing. Retention of urine during convalescence does not seem to be nearly so common as formerly. If the patient is ignorant of the possibility and is treated with an easy confidence and assurance, the catheter will probably not be necessary. If wound-healing is satisfactory the patient may be allowed out of bed during the third week and may begin to walk during the fourth. Occupations not involving strain or long standing may be resumed in five weeks, but laborious work should not be started until three or four months after a satisfactory operation and wound-healing.

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[*] " Inguinal Hernia," 1919, London, Churchill.
[†] *Lancet*, 1899, ii, 1353 ; 1902, i, 1519 ; 1904, i, 727.
[‡] *Brit. Med. Journ.*, 1907, ii, 1389.
[§] *Lancet*, May 4, 1940, i, 822.

Complications and sequelæ.—*Hæmatoma* of the cord may give rise to a hard mass or nodule which is always mistaken by the patient for a recurrence, causing much disappointment and anxiety. Beyond a suspensory bandage no special treatment is necessary, but it may be several weeks before absorption is complete. *Ærocele.*—On very rare occasions the area from which the sac has been removed becomes occupied by imprisoned air. This will always safely absorb but if the process is unduly slow the air may be removed by aspiration. *Hydrocele* may occur but is not nearly so frequent since surgeons have given up removing the veins of the cord. When it occurs it should not be hastily interfered with. Tapping and the use of a suspensory bandage often bring about cure. *Atrophy of the testicle and painful testicle* only occur when the blood supply of the organ has been interfered with either by removal of the veins, or their obliteration following thrombosis, which may be a rare sequel to the inevitable handling during operation. *Painful scar* is another but fortunately rare sequel. The cause is obscure and the condition does not yield to local treatment. Most benefit follows physiotherapy.

The operation to be employed at various ages.—In this matter there are no definite criteria. A useful working rule is as follows:—Up to two years of age, the sac is separated and ligatured off as high as possible without dividing the external oblique. One or two sutures may be used to draw the external ring together if the hernia has been very large. Between two and twelve years, the external oblique is divided over the canal so that the sac can be isolated and ligatured off at the highest possible point, and the conjoined tendon is sutured to Poupart's ligament superficial to the cord, i.e. without displacing it. After twelve years of age, the Bassini operation is always employed.

Double inguinal hernia.—It has been suggested that there is a greater risk of recurrence when operations for double inguinal hernia are carried out at the same sitting, and there is some statistical evidence in support of this contention. It is probably quite safe to do the double operation simultaneously in children, but in adults the temporary rigidity of the parts about the sutured canal results in more strain being thrown upon them by vomiting, coughing or post-operative distension. If only one side is dealt with at a time the intact side will be more elastic and will carry some of the strain, and in this way relieve the operated side. It appears to me that this is reasonable, and I have recently adopted the practice of dividing the operation. It is logical to allow a sufficient time for consolidation to be completed, and the interval should not be less than from 4 to 6 weeks. It is important to be assured that no chest complication has occurred in the interval, and this should not be overlooked even after a local anæsthetic.

Operations in children.—It is often a help to raise the pelvis with a small sandbag or cushion beneath the buttocks. The only special difficulty is to identify and isolate the rather delicate sac. The subcutaneous tissue is often so plentiful that an ample incision is necessary to expose the region of the external ring. The structures of the cord are often spread out over the sac and great care must be taken not to tear the vas or the vessels. If there is difficulty in finding the margin of the sac it is better to incise in a direction parallel with the cord, when the sac will eventually be opened and a finger can be introduced into its interior as a help in separation. If the sac is of the congenital type it must be divided above the testicle. The lower part is left to form a tunica vaginalis, but it is not necessary to close it by ligature or suture. The upper part is separated and ligatured off. (Fig. 509.)

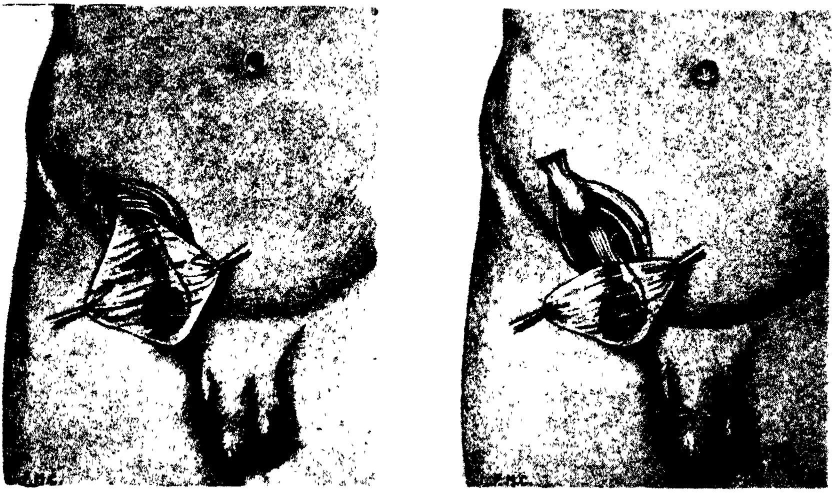

Fig. 509.—Method of isolating sac in congenital hernia.

Hernia with imperfect migration of the testicle.—When this condition is encountered before the age of 10 or 12 it is probably best not to interfere surgically, as the growth of the hernia may encourage descent of the testicle. Of course strangulation or attacks of pain or great increase in size would make operation imperative. Should operation be called for, the hernia must be dealt with as described. After the isolation and removal of the sac it may be possible easily to mobilize the testicle so that it can be placed in the scrotum, when it must be dealt with as described elsewhere (p. 2174). When operation for the hernia must be carried out in very young children and the testicle is small and delicate, it is probably better merely to deal with the hernia and to leave the testicle in its abnormal position either for a trial of hormone treatment or to be dealt with by operation some time between 12 and 14 years of age, if it has not descended naturally in the meantime. When operating, great care must be taken not inadvertently to remove the testicle with the sac. In older children and adults the radical cure can be combined with the operation for the testicle, usually by the Keetley-Torek method.

Operations for bubonocele.—In this condition there may be no proper sac, merely a general or localized bulging of the peritoneum, either external or internal to the deep epigastric artery or both. It is then only necessary to separate the bulging portion from the muscle-edges and to invert it towards the abdomen, closing the canal by suture of the conjoined tendon to Poupart's ligament. When not too tense, the external oblique should be overlapped.

Operation in the female.—The external oblique should always be divided over the length of the canal. The sac may be so closely incorporated with the round ligament that it may be very difficult to separate them ; in these circumstances they may safely be ligatured off together. In other cases the sac can readily be identified and separated from the ligament. After dealing with the sac the conjoined tendon is sutured to Poupart's ligament superficial to the round ligament and the canal is completely closed by careful suture of the external oblique. When the sac descends into the vulva it is often difficult to separate, and there may be a good deal of venous hæmorrhage as a result. In such cases it may be safely cut across at the upper part of the vulva, leaving the fundus in situ. The part of the sac left behind becomes obliterated.

Sliding hernia.—In this variety, the mesentery of the contained bowel is incorporated with the sac so that what would be the posterior wall of the sac is occupied by the extraperitoneal tissue carrying the mesentery with its vessels. On the right side such a hernia may contain the cæcum with part of the ascending colon and the termination of the ileum, and on the left some part of the sigmoid. The separation of the mesentery from the cord is usually a matter of considerable difficulty and involves the risk of injury to mesenteric vessels. As a rule, the surgeon must be content to remove only a portion of the sac, and the remainder with its contents is then returned as far as possible into the peritoneal cavity or into the extraperitoneal tissues. The canal must then be closed in the usual way.

Quite often the opening in the peritoneum after part of the sac has been removed cannot be ligatured in the ordinary way but must be closed by a continuous suture. Fortunately the neck of the sac in this variety of hernia is always wide and there is little risk of strangulation.

Unusual contents of the sac.—Except for the appendix, any part of the viscera found in a hernial sac should be returned to the abdomen. Every effort should be made to reduce omentum, but sometimes it is so diffusely adherent and so much hypertrophied that it cannot be separated or returned to the abdomen. In these circumstances it may have to be removed. Great care must be taken in ligaturing off omentum, as many serious accidents have occurred from the retraction of large vessels. It should be taken up in small sections and should not be divided too close to the ligatures. Catgut should be employed, as a sort of chronic inflammation, " omentitis " (epiploitis), has sometimes followed the use of silk.

The appendix in the sac.—If the part of the cæcum from which the appendix arises is also in the sac, it is best to remove the appendix. The same may be said if the cæcum can easily be drawn down into the sac exposing the base of the appendix. No attempt should be made to remove the appendix unless its attachment to the cæcum can be easily exposed. If the appendix is not to be removed, care must be taken to avoid damaging it by forceps.

The bladder in the sac.—This is most frequently found in direct hernia, but it may occur in the oblique variety. In either case it is commonest in those who are obese or extremely flabby. Very rarely, a portion of the peritoneum-covered bladder may be a free content of the sac, but much more usually it bears an extraperitoneal relationship to the inner side of the neck and is usually exposed when the latter is being isolated preparatory to ligature. It appears as a rounded mass of fat which does not easily separate from the sac. On opening into this fat, the muscular fibres of the bladder may be seen. It is a good rule to remember that if the neck of the sac cannot be cleared by gauze-stripping the bladder is probably adherent. In such circumstances no attempt should be made to separate the viscus, but the ligature should be applied below it. If the bladder is inadvertently injured, the tear must be closed by suture and it is better to bring a small rubber drain from the site out of the inner angle of the parietal incision.

Lipomata of the sac.—These tumours are not infrequent, though there is usually nothing to indicate their presence before operative exposure. They are soft elongated masses of fat with a pedicle attached above the level of the internal ring. As a rule, they are noticed when clearing the sac and are very easily separated from it and from the cord. They should always be removed, either with the sac or after the latter has been dealt with. The small leash of vessels which run in the pedicle requires ligature. In long-standing hernias fibromata may be found in the sac wall, usually near the fundus ; cysts of various sorts also occur. These conditions are of academic interest and will usually be removed with the sac.

Injury to the vas.—This may be cut cleanly through or torn, or a section may actually be removed. In all but old men it should always be repaired. If frayed or irregular, the ends must be cut cleanly across : they can then be approximated and held together by a couple of fine catgut stitches passed through the cellular tissue which forms a sheath for the structure. Some surgeons advise that a fine stitch on a straight needle should be passed into the lumen of either end for a short distance to ensure that the channel is united end to end.

Injury to the femoral artery or vein.—These vessels have been punctured during the passage of the deep sutures and hæmorrhage or, later, traumatic aneurysm has sometimes been the result. A cutting needle may produce quite an appreciable wound in the vessel wall. The accident is immediately followed by the escape of blood which rapidly spreads in the cellular tissue. The proper treatment is to withdraw the needle at once and to apply firm pressure to the site for about five minutes. As a rule this suffices to arrest the hæmorrhage. If it does not do so, Poupart's ligament must be strongly retracted downwards and the injured vessels exposed by stripping away the cellular tissues. The puncture can then be sutured with a small rounded needle (such as is used for cleft palate). An additional stitch in the adventitia may be necessary. A hole in the vein wall is best occluded by a lateral ligature of fine strong silk ; catgut does not take a sufficiently secure bite.

Results.—*Mortality.*—This is very small, and in the hands of trained surgeons is considerably less than 1 per cent. Coley and his co-workers, *vide infra*, had a mortality of only 0.15 per cent. in 3,358 operations.

Recurrence.—Coley and Hoguet, reporting their results at the Hospital for Ruptured and Crippled, New York, from January, 1891, to January, 1918, analysed 6,090 operations.* In 5,813 oblique inguinal hernia cases the results were :—

	Cases	*Recurrences*	*Per cent.*
In the male (97 per cent. under 15)	4,420	25	0·57
In the female (children)	690	1	0·15
,, ,, (adults)	369	13	3·5
With undescended testis	334	0	0

The results following types of operation were :—

	Cases	*Recurrences*	*Per cent.*
Bassini	3,725	14	0·38
Cord not transplanted	792	11	1·3

As so many of these cases are children, the results are better than could be expected in an adult series. Torek† reports 2 recurrences in 600 cases operated upon by his method.

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* *Ann. Surg.*, Sept., 1918, lxviii, 263.
† *Ann. Surg.*, July, 1919, lxx, 65.

Battle* found that 85 per cent. of recurrences occurred within twelve months. He stated that the three causes of recurrence were—

(1) Incomplete removal of sac.
(2) Advanced condition of secondary weakness in elderly patients.
(3) Trauma or faulty technique.

He found that in 107 recurrent cases, suppuration had occurred in only 22.

Cecil P. G. Wakeley† gave the results of a follow-up of 1,140 operations for inguinal hernia which showed a recurrence rate of 5·4 per cent. among 851 cases traced. Considerably lower and also much higher recurrence rates (Max Page, 20 per cent.) have been reported by British surgeons but 5 per cent. probably represents the average results in a cross-section of inguinal hernia at all ages and of all types in times of peace.‡ In children, recurrence ought to be practically non-existent and in healthy young adults up to 30 it should not be more than 2 per cent., but much higher figures must be expected in older patients. For accurate statistics the cases should be divided into age groups.

The results of operations for recurrence are very disappointing, and in Wakeley's series (*loc. cit.*) further recurrence appeared in no less than 38·6 per cent. There is no doubt that the best chance of cure lies in a properly executed first intervention.

These considerations emphasize the significance of the operation for hernia, which must always be classed as one of the most important in surgery. It should never be undertaken without great attention to all the details, and it is grossly unfair to the patients to hand these operations over to junior surgeons without careful supervision.

DIRECT INGUINAL HERNIA

The attempt to cure direct inguinal hernia is of comparatively recent date. The condition is acquired as the result of muscular degeneration of the internal oblique and transversalis, while generally the aponeurosis of the external oblique has lost much of its tone. In some few cases the sac actually passes through a hole in the conjoined tendon. The sac lies to the inner side of the deep epigastric vessels, and is not rarely associated with an oblique inguinal sac. Often it is nothing more than a bulging of the peritoneum, but so relaxed are the structures that the bladder is often found in association with the sac, and must always be looked for.

The usual Bassini's incision is made, and the aponeurosis of the external oblique divided in the direction of its fibres. The two flaps are turned back, the lower until the upper grooved surface of Poupart's ligament is cleared, the upper so as to expose not only the conjoined tendon for a width of an inch, but also the sheath of the rectus abdominis in its lower two inches. The sac is then cleared and carefully defined, and the presence or absence of an associated oblique sac verified. The cord will be found external to (in front of) the sac, and is usually easily separated. If there is a double sac, direct and indirect, it may be necessary to ligature and divide the deep epigastric vessels, or it may be possible to raise them and, by passing a pair of pressure forceps behind them from above, to lay hold of the direct sac and withdraw it behind the vessels to the outer side, thus converting the sacs into a conjoint oblique sac. It is said that this manœuvre lessens the risk of damage to the urinary bladder ; it is certainly the best plan when there are two definite sacs. The neck of the sac is often very wide, so that it may be impossible to transfix and tie in the ordinary way ; in such a case it should be opened, the contents reduced (they are rarely adherent), and the edges trimmed so that they may be united by a running suture in the way that the peritoneum is closed after laparotomy. The cord is held aside and sutures are applied to close the gap in the musculo-aponeurotic wall. It will be found impossible in many cases to form a sufficient barrier by a simple suture of conjoined tendon to Poupart's ligament. To supplement this, Wölfler, in 1892, suggested that the rectus muscle or its sheath should be utilized. This may be done in one of three ways : (*a*) the lower two inches of the outer border of the rectus muscle in its sheath is sewn down to the inner surface of Poupart's ligament without mobilization ; (*b*) the rectus sheath is opened, the muscle mobilized, and the outer edge sutured to the inner surface of Poupart's ligament ; or (*c*) a flap is made from the anterior layer of the sheath, its base at the outer border, and this flap is turned down, the attached edge acting

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* *Lancet*, 1908, ii, 601. † *Lancet*, May 4, 1940, i, 822.

‡ The reader should consult " Inguinal Hernia," a Critical Review by Brigadier Harold Edwards, *Brit. Journ. Surg.*, No. 122, 1943, xxxi, 172.

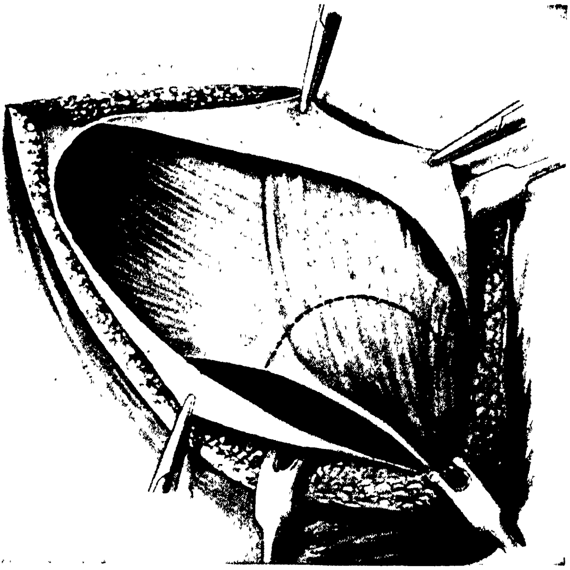

Fig. 510.—Radical cure of direct inguinal hernia. Internal oblique aponeurosis exposed and area of flap from rectus sheath marked by dotted line.

(Reproduced by permission of Mr. Geoffrey Keynes.)

as a hinge, and is sewn to the inner aspect of Poupart's ligament. (Figs. 510, 511.) All these methods have their particular disadvantages. Method (*a*) may be impossible owing to the absence of mobilization; method (*b*) weakens that part of the abdominal wall which depends on the rectus muscle; method (*c*) gives a comparatively inefficient barrier which, owing to the weakness of the posterior sheath of the rectus at this point, is not very firmly attached at its "hinge." My preference is for method (*b*), which gives a substantial barrier with a resulting weakening of the abdominal wall that is more theoretical than actual. Close attention must be paid to the point at which the conjoined tendon meets the outer edge of the rectus. When all the sutures are tied so as to draw the musculo-aponeurotic structures over the gap behind the cord, the aponeurosis of the external oblique is sutured superficial to the cord, additional security being obtained, especially if the aponeurosis is lax, by overlapping the inner flap over the outer, the free edge of the latter being sutured to the sheath of the rectus in its lower part. Living sutures of fascia lata (Gallie's method) or strips cut from the edge of the divided external oblique and left attached at one end, have been especially useful in direct hernia, where the muscles cannot be approximated without tension or where they are particularly weak and friable. The strips of fascia are used as sutures for the deeper part of the operation. No attempt is made to approximate the structures if there is great tension, the fascia being used to form a network between the two. A second fascial strip is

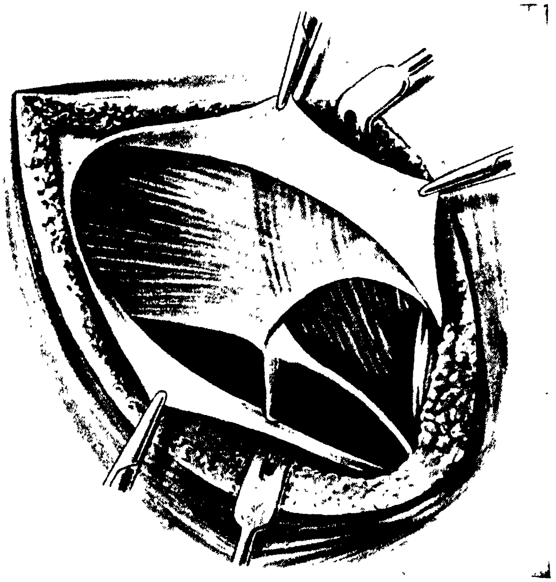

Fig. 511.—Radical cure of direct inguinal hernia. The flap has been reflected and sutured to Poupart's ligament.

(Reproduced by permission of Mr. Geoffrey Keynes.)

used to weave the abdominal aponeurosis and the rectus sheath to Poupart's ligament. This suture starts at the internal abdominal ring and ends at the spine of the pubis. It is interwoven with the first to make a sort of mat over this part of the abdominal wall.

Results.—As might be expected, the results compare badly with those of the ordinary Bassini operation on selected cases. Downes and Erdman give 15-20 per cent. of failures,* and Max Page,† in a follow up of operations on London policemen, found a recurrence rate of no less than 25 per cent.

FEMORAL HERNIA

This type of hernia may be approached either from above or below Poupart's ligament. Until about the last twenty years the lower operation was almost universally employed. This **lower route** has undergone no modification for many years. An oblique incision is made over the hernia parallel with and about half an inch below Poupart's ligament. (Fig. 512.) This gives as good an exposure as the vertical incision sometimes recommended, and heals perfectly, whereas the vertical scar often becomes thickened and contracted and, for a time at least, interferes with the free movement of the thigh. The incision is deepened until the sac is reached. The latter forms a rounded firm mass which is readily identified and can be separated from the cellular tissue in which it lies by sweeping the finger around it. The sac must then be opened and the contents dealt with. Quite often it contains only some serous fluid which is apparently shut off from the peritoneal cavity. Having been emptied, the sac can be readily isolated up to the crural opening ; it is usually adherent to the margins of the latter but can be freed by dissecting forceps or a few touches of the knife. Having thus been released, it must be drawn down so that it may be ligatured off at the highest possible point, the object being to avoid a cul-de-sac which would invite recurrence. The surgeon must remember that the femoral vein is in close relationship to the neck on its outer side. If the neck is small it may be transfixed and tied, as in inguinal hernia, but if it is large and fleshy it should be closed by a continuous suture. The sac itself is cut away, the division being made well beyond the ligature. In either case the stump of the sac is pushed with the finger through the crural opening into the extra-

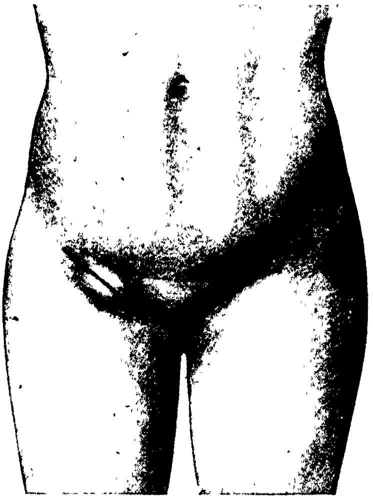

Fig. 512. — Oblique incision below Poupart's ligament for femoral hernia.

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* *Ann. Surg.*, 1911, liii, 568.

† *Brit. Med. Journ.*, 1934, ii, 896.

peritoneal tissue in the pelvis. If the hernia is small and the neck has been properly exposed, ligatured and reduced into the pelvis, this will suffice and nothing beyond closure of the skin incision is necessary. If the femoral opening is large enough to admit the tip of the forefinger, then it must be closed by inserting one or two sutures between the inner end of Poupart's ligament and Cooper's ligament. It is not enough merely to stitch Poupart's ligament to the pectineal fascia. The sutures must not be thinner than No. 1 chromicized catgut and are passed with a small, fully curved, round needle on a holder. They are most conveniently introduced if the surgeon stands on the opposite side of the patient. Having perforated the inner end of Poupart's ligament, the needle is made to enter the pelvis just over the brim, and its point is gradually lifted until it can be passed under the strong band of fascia running along the pectineal ridge which is known as Cooper's ligament. (Fig. 513.) It is seldom necessary to use more than two sutures and care must be taken not to perforate or compress the femoral vein. The subcutaneous fat can be tacked to the pectineus to help to obliterate the space previously occupied by the sac. The skin incision is conveniently closed by a subcuticular suture of fine catgut.

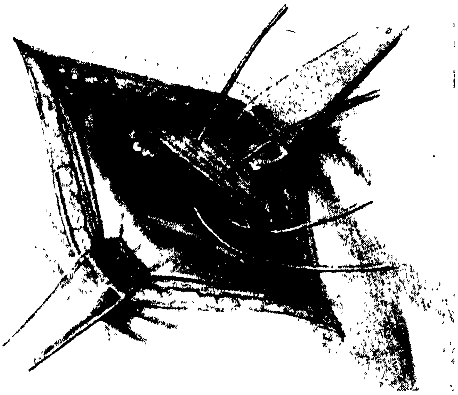

Fig. 513.—Radical cure of femoral hernia by the lower route. Sutures passed through Poupart's and Cooper's ligaments.

For hernia up to the size of a hen's egg, this operation, if properly carried out, is most satisfactory, though the following objections have been urged against it.

(1) It is practically impossible to remove the sac flush with the peritoneum—fortunately perhaps, as the bladder is often in close relation with the neck of the sac.

(2) It is difficult, if not impossible, so to apply sutures that the crural ring is closed.

(3) The obstruction of the femoral canal by sutures is valueless.

(4) In strangulated hernia, division of the stricture is not without

danger, and enterectomy and anastomosis are usually impossible through the incision.

Radical cure of femoral hernia by the upper or inguinal route (Lotheissen's or Parry's* operation).—In view of these and other possible disadvantages, it is not surprising that attempts were made to cure femoral hernia by approaching the crural ring from above. Though Annandale, as long ago as 1876, and Tuffier in 1894,† recommended the inguinal route, it is only of recent years that it has been at all generally adopted. The approach from above is easy; exact clearance and ligation of the neck of the sac are practicable; the bladder is not in danger, as it can be recognized and easily avoided; and the crural ring can be seen and accurately sutured. In strangulated hernia the advantages of this route are obvious, as Gimbernat's ligament can be divided or stretched under direct vision, the sac can be opened at the neck and, if the gut is gangrenous, it is simple to open the peritoneal cavity further and do what is necessary in the way of resection. The only disadvantage is that it is sometimes difficult to withdraw the sac from the canal because of its size or its fixity; but the surgeon must never be tempted to divide Poupart's ligament to effect this. When the predicament arises, then, by enlarging the inguinal incision, it may be possible to retract the lower skin flap below the level of Poupart's ligament, so that the sac can be exposed and separated in the crural canal. In a very obese subject it may be necessary to make a vertical incision from the centre of the horizontal one, downward over the crural canal, through skin and subcutaneous tissue, in order to expose and separate the sac from below.

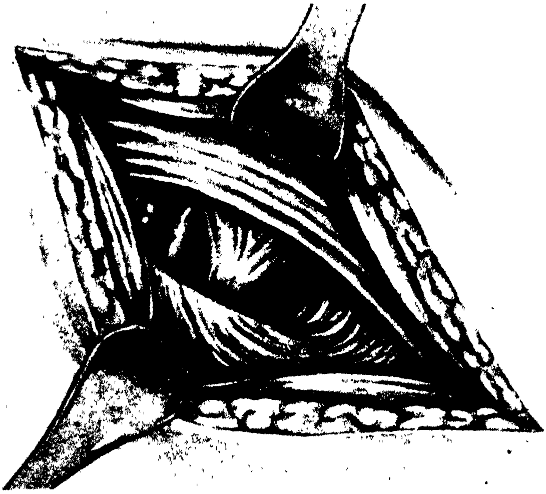

Fig. 514.—Radical cure of right femoral hernia by inguinal route: neck of sac defined.

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* *Brit. Med. Journ.*, Oct. 19, 1901, ii, 1136, "Radical Cure of Femoral Hernia," by R. H. Parry.
† *Rev. de Chir.*, 1896, xvi, 240.

Originally a curved incision was used, with the convexity downwards, making a flap over both femoral and inguinal regions, but it is now usual to make the same incision as for inguinal hernia. The aponeurosis of the external oblique is divided in the direction of its fibres, the edges being retracted. The conjoined tendon is drawn upwards, and the cord or round ligament isolated and looped out of the way. The transversalis fascia is divided in the line of the incision up to the deep epigastric vessels, but the peritoneum is not opened. All fat and areolar tissue is wiped aside by gauze stripping, until the neck of the sac is isolated and the deep epigastric vessels, or even the external iliac vein, are demonstrated. (Fig. 514.) The sac is now separated from the crural ring—which is plainly seen on retracting Poupart's ligament downwards—and withdrawn from the canal. (Fig. 515.) The sac is opened, its contents are reduced, and it is then transfixed, tied off, and cut away as near the general peritoneum as possible. The ends of the suture are left long and are threaded on a needle which is passed from within outwards through the conjoined tendon, and knotted on the outer surface under cover of the upper flap of the external oblique aponeurosis. The next step is to close the crural ring. This can be brought immediately under inspection, by retracting the lower flap of the aponeurosis of the external oblique, including Poupart's ligament. The ring is bounded on the inner side by Gimbernat's ligament, on the outer side by the femoral (external iliac) vein, in front by the deep fibres of Poupart's ligament, and behind by Cooper's ligament and the iliopectineal line. The closure is effected by two or three interrupted sutures which must take a good hold of the inner end of Poupart's and Cooper's ligaments. The number of sutures is determined by the size of the crural opening but, as a rule, two or three at a distance of three-

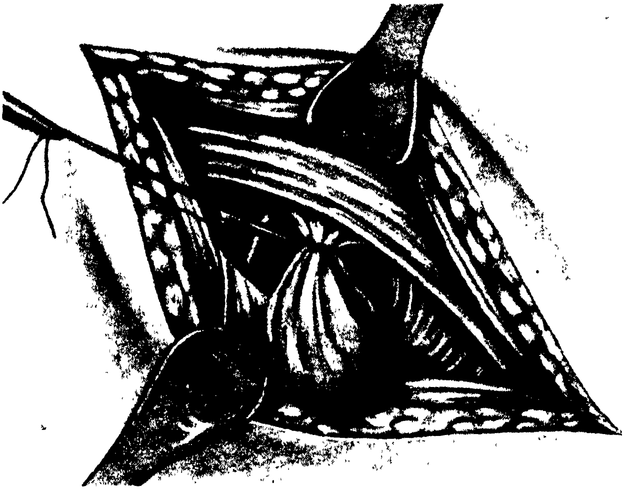

Fig. 515.—Radical cure of right femoral hernia by inguinal route : sac withdrawn from femoral canal and neck ligatured.

eighths of an inch apart will suffice. The sutures are passed with a small rounded needle mounted on a holder. Care must be taken not to compress the vein, which is readily seen. (Fig. 516.)

In the original method the conjoined tendon is now sutured to Cooper's ligament, the first suture taking a hold of the edge of Gimbernat's ligament and the operation is completed as for inguinal hernia. When the parts are widely separated or when the conjoined tendon will not draw down without tension, a flap may be cut from the sheath If the rectus and turned down as suggested by Keynes (Figs. 510, 511). on most cases it will suffice to complete the operation by suturing the conjoined tendon to the upper aspect of Poupart's ligament, just as in the radical cure of inguinal hernia, taking the same precautions as to direction of insertion and degree of tension when knotting. The aponeurosis of the external oblique is united by a series of interrupted sutures and the incision closed. (Fig. 517.)

Several other operations for this type of hernia have been devised but they do not seem to possess any outstanding superiority. Those methods in which Poupart's ligament is divided or detached are to be avoided.

Results.—The end results are satisfactory and, with the exception of the very large hernias or cases complicated by strangulation, there are few recurrences. In 535 cases Wakeley (*loc. cit.*) found a recurrence rate of 4·6 per cent.

The mid-line extraperitoneal approach for groin hernias.—This method, which was described by A. K. Henry,* was suggested by the ease with which the femoral ring could be seen during the extraperitoneal exposure of the ureter. It was subsequently noticed that the route was almost equally convenient for some of the inguinal hernias and that both the femoral ring and the internal inguinal ring could be easily and securely closed from their abdominal aspect. The method has the advantage that the funnel-shaped process of peritoneum superior to the neck of the sac can be readily isolated and removed with the sac. A. K. Henry has found the plan particularly useful for bi-lateral hernias or for combined inguinal and femoral hernia.

Technique.—The patient lies on the back with both trunk and thighs slightly flexed, to relax the lower abdomen. The Trendelenburg position may be a great advantage. A mid-line incision is made, extending from the umbilicus to the pubes. This reaches the extra-peritoneal tissue but the peritoneal cavity itself is not opened. By blunt dissection with the finger, commencing below and laterally, the peritoneum is readily separated from the muscles in an outward and upward direction until the abdominal aspect of the hernial region is exposed. The peritoneum, as it approaches the hernial canal, appears as a funnel-shaped process leading to the sac and can be readily isolated with the finger and drawn up into the abdomen. If,

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* *Lancet*, 1936, i, 531.

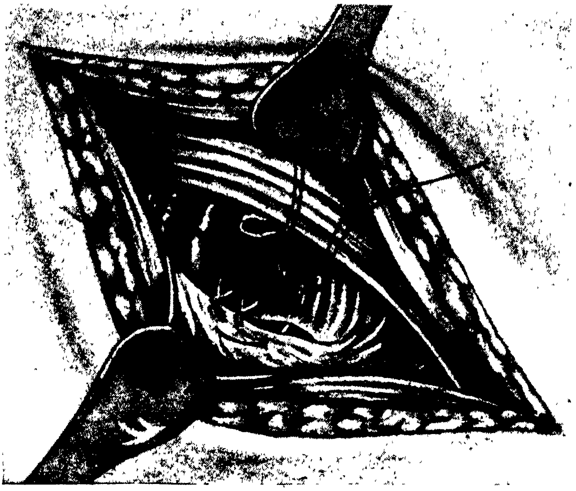

Fig. 516.—Radical cure of right femoral hernia : closing femoral ring ; sac ligatured and retracted under conjoined tendon.

as happens in some cases, usually inguinal hernia, the sac cannot be so readily drawn into the abdomen, its upper part may be isolated and cut across below the neck, the fundus being left *in situ* in the scrotum. After free mobilization the sac is either ligatured off well above the neck and removed, or is cut away at its origin, the resulting aperture in the peritoneum being closed by a purse-string suture. In femoral hernia the mouth of the femoral canal can then be closed by turning up a flap from the fascia covering the pectineus and suturing it to the hinder edge of Poupart's ligament. In inguinal hernia the internal

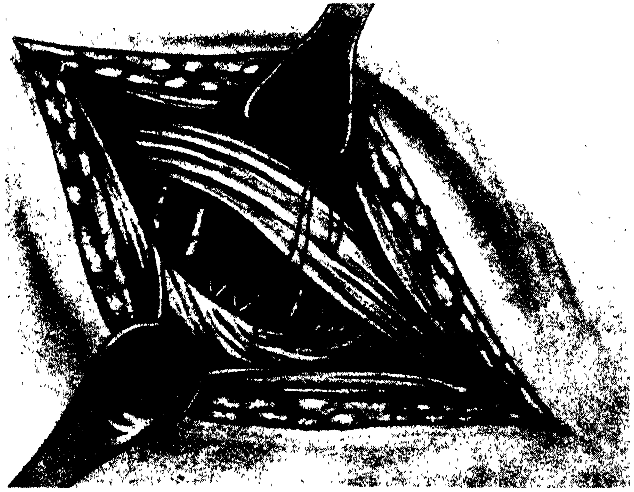

Fig. 517.—Radical cure of right femoral hernia : closing inguinal canal, conjoined tendon sutured to upper surface of Poupart's ligament.

ring is closed by two or three interrupted sutures drawing together the deep surface of its boundaries from above downwards, thus narrowing the ring down to the point where it transmits the cord. The method is not suitable for large irreducible or strangulated hernias. In suitable cases the after-results have been very satisfactory.

UMBILICAL HERNIA

The common type of umbilical hernia is met with in the adult female between about 35 and 50 years of age ; it also occurs in the male, but very much less frequently. The protrusion takes place about, rather than through, the umbilical cicatrix, so that these hernias are sometimes spoken of as para-umbilical, but this is a point of no practical significance. What is much more important is that in many cases the beginning of the hernia has persisted from infancy and has become steadily larger as the result of child-bearing and obesity. In the umbilical hernia of adults the fibrous structures of the midline are much stretched by the wide separation of the recti. As a consequence the interval between the muscles may be two or three inches, and this space is occupied by a strong sheet of fibrous tissue to the inner aspect of which the peritoneum is closely adherent. The neck of the hernia is represented by a circular aperture in this tissue with edges which are well-defined and sharp. The sac itself is closely adherent to the overlying skin, and its interior is often divided into loculi by strong fibrous septa. The usual contents are some portion of both large and small intestine together with great omentum. In the very large hernias most of the abdominal viscera may be in the sac. The colon and omentum are commonly diffusely adherent to the sac but there may also be general adhesions fixing coils of small intestine to one another and to the wall of the sac. It is also quite usual to find adhesions around the abdominal margins of the hernial orifice. The hernia may be of great size and, as the patient is generally fat, it is really larger than it appears to be, so much of the sac being hidden in the subcutaneous tissues which are often several inches deep. (Fig. 518.) Operation is attended by danger, not only of failure to secure a radical cure, but also to life, for a large proportion of these patients are poor surgical risks in many ways. However, there is so great a tendency to strangulation, and the mortality of this complication in umbilical hernia is so heavy, that a radical cure should always be attempted, if the general condition of the patient does not imperatively forbid it. This statement is strikingly illustrated by the results in a series of my own cases up to 1924. The operative mortality in 103 non-strangulated cases was only 0·97 per cent., whereas in 36 operated upon for the relief of strangulation the death rate was 36·11 per cent.

Almost the only absolute contra-indication is a hernia so large that the abdominal cavity either cannot accommodate the contents or can only do so at the expense of serious respiratory embarrassment from the crowding of the viscera up under the diaphragm. In view of the frequency and high mortality of strangulation, diabetes, chronic cough and increasing obesity are indications for careful preparatory treatment rather than contra-indications to operation.

Preliminary treatment.—Consideration of the causes of death after operations in this type of hernia emphasizes the necessity for careful and perhaps prolonged preparation. Many of these patients are subject to bronchitis with emphysema and fatty dilated heart. The anæsthetic may light up a quiescent bronchitis, and the return of the massive contents of a hernia into an abdominal cavity which has, perhaps for years, been relieved by the safety-valve action of the additional accommodation provided by the hernial sac, coupled with tight suturing, throws a great strain on the already weakened heart. Many patients, also, have glycosuria, renal insufficiency and high arterial tension. The question of preparation must be carefully considered, and a routine investigation made, special attention being paid to the condition of the heart and circulation, and the renal function.

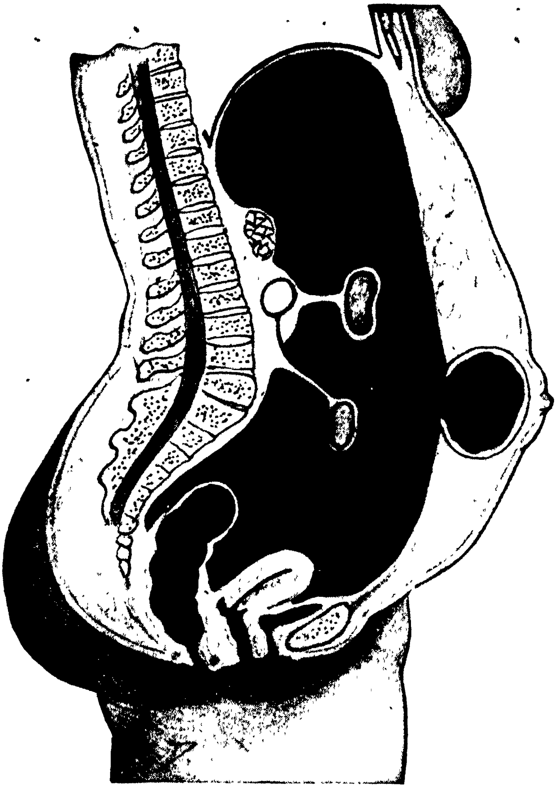

Fig. 518.—Shows sac of umbilical hernia buried in fat of abdominal wall.

(By permission of Mr. Geoffrey Keynes.)

Operation should be deferred until such conditions have been investigated and efficiently treated.

Great attention must be given to the bowels, which should be freely moved and, if necessary, thoroughly cleared out by enemata from time to time. While all flatulent foods should be excluded from the diet, the strength and general stamina of the patient must not be allowed to suffer from too strict a dietetic regimen. Whenever the kidney function is inhibited, the patient is given large quantities of dilute cream-of-tartar solution, and the intake and output are recorded. Operation must not be undertaken until the kidney function reaches a safe level and remains there. Many of these subjects have led sedentary lives and are greatly benefited by regular walking exercises, but others are hard-working housewives and for them a week or two in bed may be the best preparation. A course of medicinal treatment with nux vomica, digitalis and ammonium carbonate is very valuable.

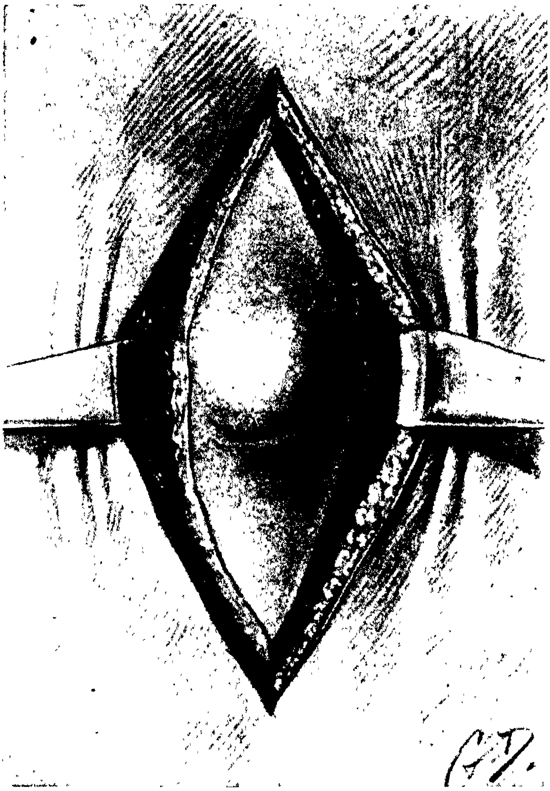

Fig. 519.—Radical cure of umbilical hernia by anatomical reconstruction : incision deepened.

The preparation of the skin is important, for there is often a moist crease below the sac which is apt to be infected. In the larger hernias the skin over the summit is not infrequently ulcerated. A few days' delay until these parts can be got into good condition will be well-spent time.

Choice of operation.—There are many plans by which the principles for the radical cure of hernia can be applied to the umbilical variety. The important consideration to bear in mind is that for the closure of the defect in the parietes the aim must be to get the parts together and to hold them without tension until natural healing can occur. Very small hernias can often be repaired by a couple of superimposed purse-string sutures reconstituting the umbilical cicatrix. In hernias not more than about two inches in diameter, the opening will not be larger than will admit the thumb, and the sac can be removed and the abdominal wall reconstructed vertically in the middle line. When larger than this, the gap through the parietes will probably easily admit 3 or 4 fingers ; with such an opening the abdominal wall cannot be reconstructed and no attempt must be made to separate the margins of the opening into its constituent layers. The conjoined structure surrounding the opening is very strong and will hold sutures, but when separated into layers these are thin and friable. If the margins can be turned in vertically or overlapped horizontally (Mayo's method) without tension, either of these methods may be employed, otherwise such large hernias are only suitable for repair by Gallie's living-suture method. In actual practice the Mayo method is the most generally useful and satisfactory.

Choice of anæsthetic.—This question is important. Acute or chronic chest infections and strangulation, with regurgitant vomiting, are indications for local or spinal anæsthesia. The local infiltration method is quite satisfactory but an unusually large amount of solution may be required and the intervention may take a long time. When not contra-indicated, general narcosis by the gas-oxygen-ether sequence is very satisfactory.

Technique.—An elliptical incision is made, either vertical or transverse (Figs. 519–526), to enclose a large area of skin covering the sac. The surgeon is apt to remove too little, but it is essential in any case to remove all the pendulous portion. To provide a sufficient exposure the ends of the incision must be prolonged well beyond the ellipse. The incisions are deepened (Fig. 519) until the aponeurosis is reached, and then, by dissecting the fat carefully off this structure towards the neck of the sac, the edges of the hernial opening can be defined.

The unopened sac with its cap of skin now stands like an island separated from the fat of the abdominal integument by a considerable interval. At this stage it may be possible to decide whether the recti muscles are too widely separated to be sutured. If they can be drawn together without tension the " ideal " operation should be proceeded with. A vertical incision is made in the middle line above the upper margin of the hernial orifice, at the point, if possible, where the separation of the recti begins. This incision is through the linea alba only, the peritoneum being so far unopened. When the incision approaches the upper margin of the hernial orifice, it divides to enclose the protruding sac, the incision being still kept in the aponeurosis, but quite close to the margin of the hernial orifice. At the lower margin the right and left incisions join again, and the midline incision is prolonged downwards till a point is reached where the recti muscles once more approach each other. The peritoneum is then separated from the rectus sheath until it is possible to lift up the unopened sac with its contents.

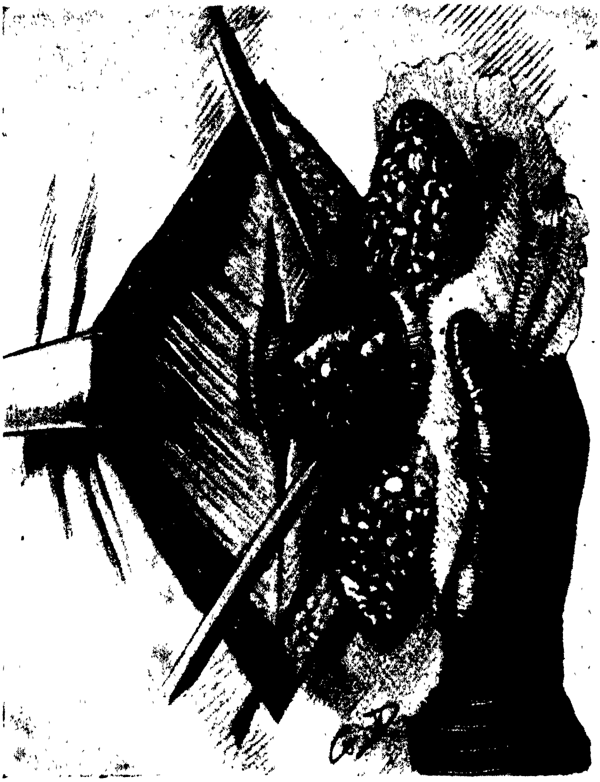

Fig. 520.—Radical cure of umbilical hernia : opening sac.

The next step is to incise the neck of the sac, to open it and to deal with the contents. (Fig. 520.) Lifting up the sac with its omental stalk and aponeurotic fringe at the neck, a space is found where the finger can be passed from below into the sac between the omentum and the neck. However adherent the contents are to the sac-wall, it is rare to fail to find an interval. At this point the neck of the sac with its aponeurotic fringe is cut at right angles with scissors and the opening enlarged. The sac is gradually turned inside out, the adherent contents being peeled off its interior till all is free.

Method of dealing with the contents.—As a rule the sac contains a large quantity of omentum together with large and, it may be, small intestine. Some part of any of the viscera, except the pancreas, may be found in very large hernias. The transverse colon with its attached omentum is the most usual content and is often diffusely adherent to the anterior wall of the sac. In long-standing cases and especially in those in which there have been repeated attacks of strangulation, there are often many adhesions between the loops of intestine, the other contents of the hernia and the wall of the sac. It is necessary to deal with these contents very deliberately and carefully. As already described, the sac must be opened at the neck and the operator must then enlarge the opening with scissors, guided by the finger as to the direction in which the wall can be most safely incised. In this way the sac is gradually completely opened up and the contents dealt with systematically. As far as possible adherent omentum should be separated and returned into the abdomen, for it provides a useful covering for the intestines and may be very valuable in the event of subsequent inflammatory disturbance. When large masses have become hypertrophied, they may require removal, but great care must be taken in ligaturing them off. Any big adhesions must be carefully caught in clips or ligatured before being divided, as they may contain vessels which are apt to retract, and may account for alarming or even fatal hæmorrhage. Smaller and more diffuse adhesions are not usually so vascular, and this is one of the few operations in surgery in which apparent roughness

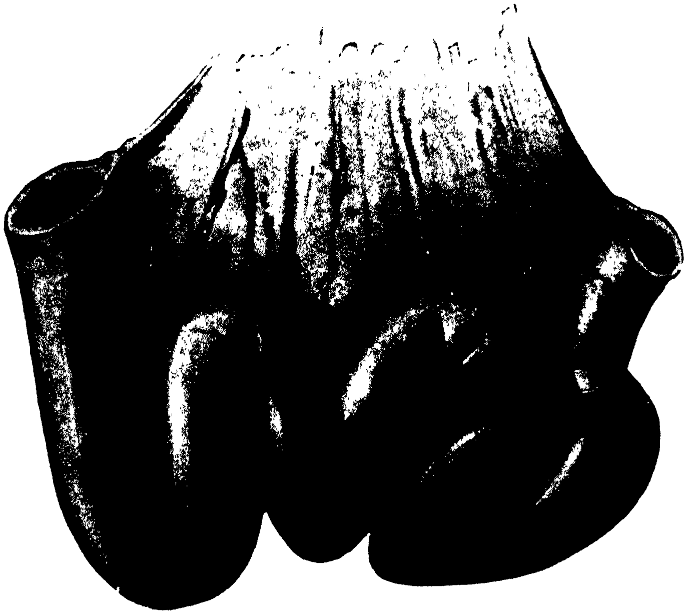

Fig. 521.—Kinked and adherent gut as frequently met with in cases of umbilical hernia.

may conduce to efficiency for, when the diffusely adherent omentum is torn away from the sac wall, there is often much less bleeding than if it is divided with scissors or scalpel. Adhesions of the bowel to the sac are more difficult to deal with and sometimes it is wise to cut away a portion of the sac and leave it attached to the intestine, with which it is returned into the abdomen. In dealing with a large hernia, and especially in cases where there have been repeated attacks of previous trouble, it may be a lengthy business so far to disentangle the contents that they can be safely returned, but it is essential that it should be done thoroughly and without undue haste. Sometimes the adhesions between the coils of intestine lying inside the sac appear as if they would invite subsequent obstruction, though the involved gut may easily be returned into the abdomen without separating them. (Fig. 521.) In this state of affairs the surgeon must use his discretion and be guided by the circumstances as to whether it is safe and wise to disentangle such adhesions or whether the gut must be returned adherent and the risk taken. If there are evident signs of obstruction or if this complication appears likely to supervene, either a lateral anastomosis should be made or the affected mass excised. In the latter event end-to-end anastomosis is best. Occasionally an

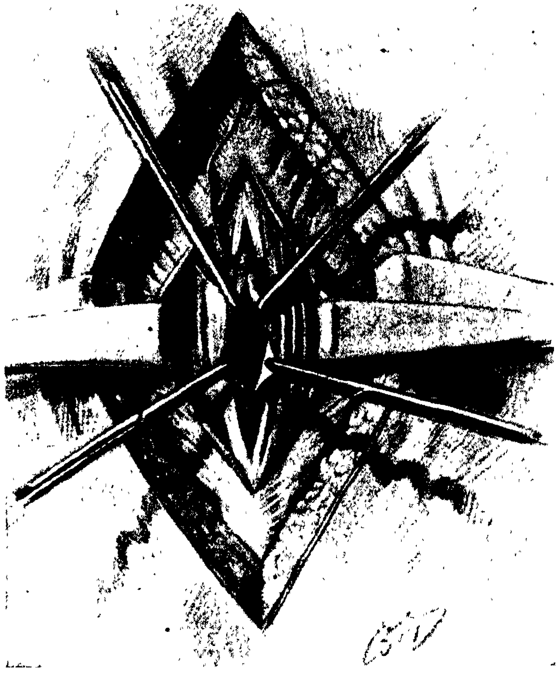

Fig. 522.—Radical cure of umbilical hernia by method of reconstruction : sac removed. Suturing of peritoneum.

inflamed appendix is found in the sac and there may even be an abscess. In these circumstances the appendix ought to be removed and the abscess cavity emptied and dried as far as possible and the parts returned into the abdomen. In any case, after the contents have been dealt with and returned, the remains of the sac must be cut away, leaving a sufficient margin for ligature or suture.

Reconstruction operation.—The peritoneum throughout the length of the incision is now closed by continuous suture. (Fig. 522.)

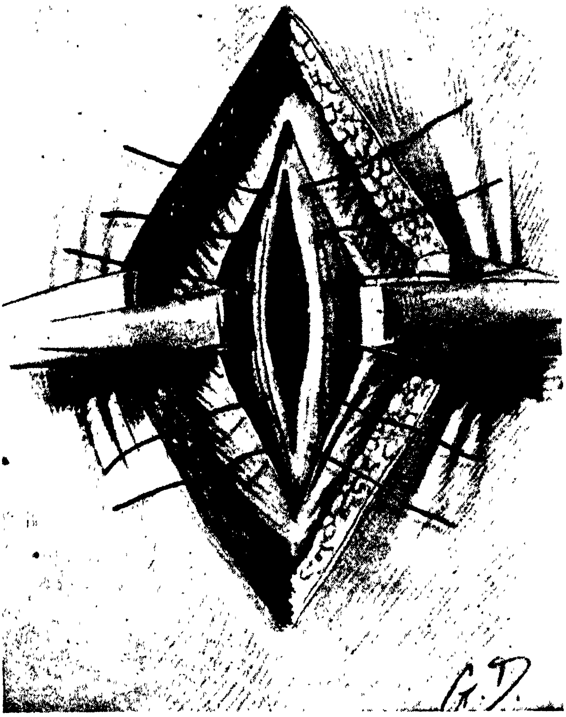

Fig. 523.—Radical cure of umbilical hernia : suture of rectus abdominis.

Beginning at the upper end of the incision in the aponeurosis, the surgeon opens the rectus sheath on both sides and identifies the edge of the muscle. This is continued throughout the length of the incision until the inner edges of both recti are free, the anterior layer of the sheath being dissected back for a short distance. The recti are now sutured together by interrupted catgut sutures passed so as to include the edge of the muscle and the posterior layer of the sheath. Great care must be taken not to make these sutures too tight, or they cut through the muscle in their grasp. (Fig. 523.) A series of silkworm-gut sutures is now passed from side to side at intervals of 2 in. through the skin and fatty integument, taking in the anterior layer of the sheath of the rectus. These sutures are tied over the gauze dressing after the skin has been sewn, and serve to obliterate dead spaces. The greatest care is taken to arrest all bleeding, for hæmorrhage between the suture layers is a common cause of failure in these operations.

The anterior layer of the sheath of the rectus is now closed, either by simple suture (Fig. 524) or by overlapping if this structure is sufficiently lax. A series of interrupted sutures unites the skin edge, and, if need be, drainage is provided. A dressing is anchored to the wound by tying over it the interrupted silkworm-gut sutures. When the aponeurosis is sufficiently lax it may be turned in by a series of mattress-sutures as shown in Fig. 525. This plan was advocated and frequently used by Rutherford Morison and yielded very satisfactory results.

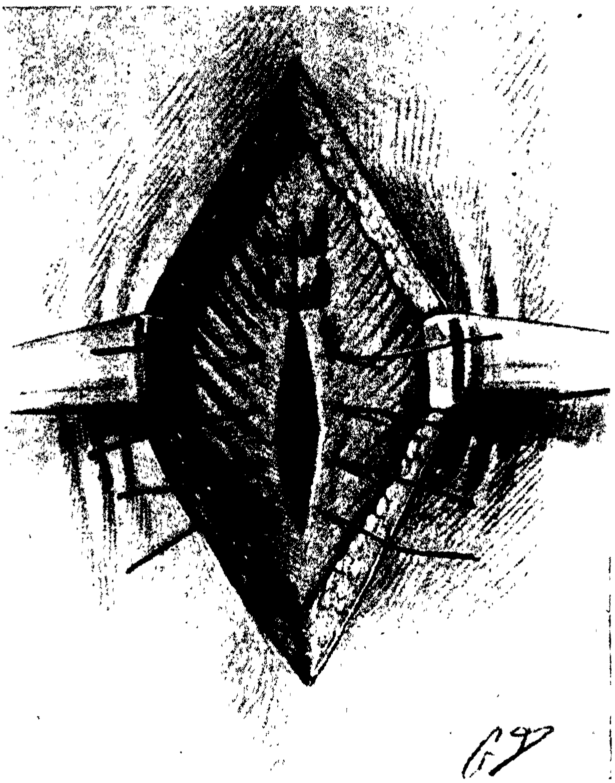

Fig. 524.—Radical cure of umbilical hernia : closing aponeurosis.

Simple transverse overlapping operation (Mayo method).—This plan may be chosen where the recti are so widely separated or so degenerated that the " ideal " operation of reconstruction is impossible. A transverse elliptical incision is made, all the pendulous portion of the protrusion being included. (Fig. 526.) The incision is deepened down to the aponeurosis, and the edge of the hernial opening defined by dissecting the fat off the aponeurosis inwards towards the sac. The aponeurosis is incised by a transverse incision passing laterally well into the anterior layer of the sheath of the rectus on each side, and skirting the hernial opening where it diverges above and below the sac. (Fig. 527.) Very often the recti are so widely separated that they lie well external to the edge of even a very large hernial aperture. In these circumstances it is not necessary to incise the

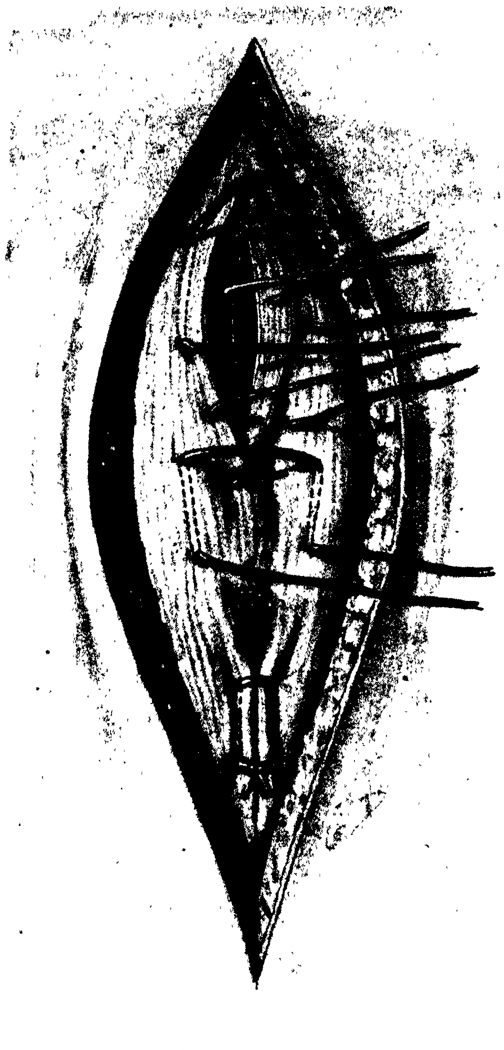

Fig. 525.—The radical cure of umbilical hernias or ventral hernias by using mattress-sutures of stout catgut to infold and approximate the aponeurosis (method of Rutherford Morison).

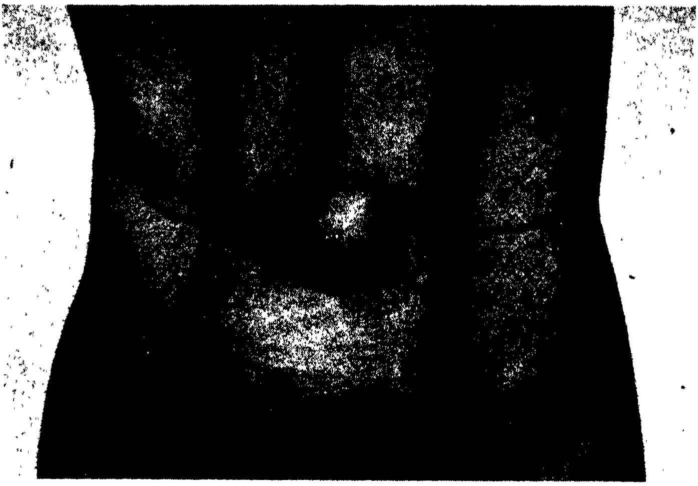

Fig. 526.—Radical cure of umbilical hernia by overlapping : transverse incision.

sheath of the rectus, as the attenuated and broadened linea alba can be satisfactorily overlapped. The sac is opened by incising the neck at a point where it is not adherent to its contents, and is turned inside out so as to peel the adherent contents off the inner wall. The remarks on p. 1077 about the method of dealing with the hernial contents apply.

In hernias of moderate size it may be possible to close the peritoneal neck of the sac by suture, but in the bigger hernias this is impossible,

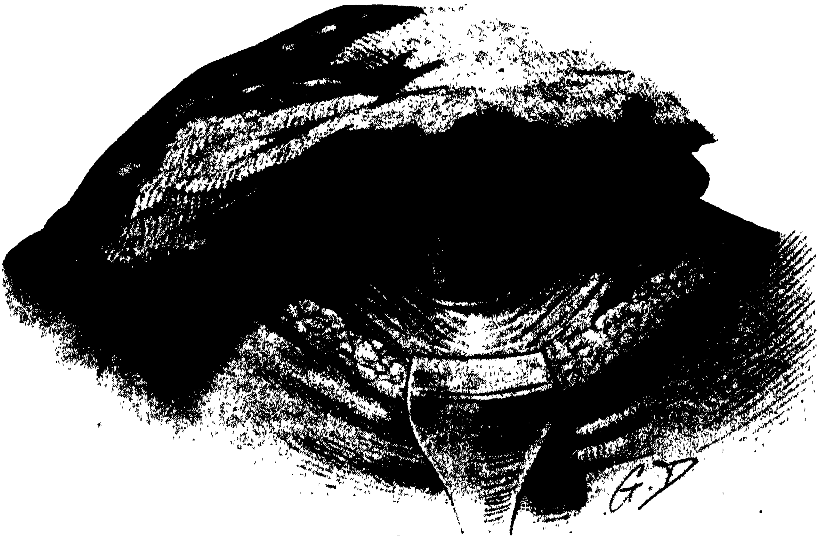

Fig. 527.—Radical cure of umbilical hernia by overlapping : neck of sac defined, and lines of incision extending to edge of rectus abdominis.

not only because of the size of the aperture but because the peritoneum is so closely adherent to what is really the greatly widened linea alba. In these circumstances the peritoneal cavity is closed by the overlap. The upper flap of aponeurosis *with the peritoneum* is made to overlap the lower. The needle, armed with thick chromic catgut No. 5, is passed from without inwards through the upper flap one or two inches from the edge ; it must then take a good hold of the lower flap and be made to emerge through the upper flap ½ in. from where it entered. (Fig. 528.) A series of these sutures is applied at intervals of ⅓ in., the lower flap is drawn under the upper, and the sutures are tied. From 3 to 5 of these mattress-sutures will usually suffice. This step should close the peritoneal cavity effectually. The upper flap must be turned upwards and any gaps between the sutures, through which tags of omentum could escape, must be closed by an independent stitch here and there. The peritoneum on the under surface of this flap is scored in various directions to promote more ready adhesion when it is applied to the lower flap. It is then turned down to lie on the lower flap and its free edge is sewn to the upper surface of the lower flap by a continuous catgut suture or a series of interrupted sutures. (Fig. 529.) Interrupted silkworm-gut sutures are inserted as in the last operation to obliterate dead spaces, all bleeding is controlled, the skin sewn up, and an anchored dressing fixed by tying the silkworm-gut sutures over the gauze. When the wound is very large or, as so often happens, the subcutaneous fat is deep and difficult to approximate accurately, it is wise to provide for drainage (*a*) to diminish the risk of hæmatoma and (*b*) to allow the

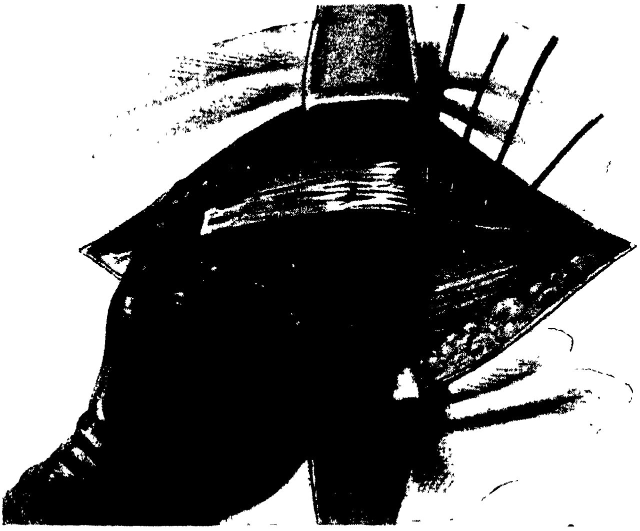

Fig. 528.—Radical cure of umbilical hernia by overlapping : insertion of sutures.

escape of broken down fat. The drainage should be by rubber tube of little finger size, brought from a small independent incision.

The dressing of these cases must be completed before the patient recovers from the anæsthetic, because the strength of the diaphragm is so great that its sudden action may easily tear away the suturing unless firmly supported. After the application of the gauze and wool, the dressing must be fixed by a many-tailed bandage of ample size. On the outside of the bandage long strips of sticking-plaster should be applied from one flank right over to the other both directly transverse and obliquely.

After-treatment.—Certain points in the after-treatment deserve special attention. These patients often have considerable respiratory embarrassment, partly because of their bulk and the tendency to bronchitis and sometimes because of the increased intra-abdominal tension from the reduction of the hernia. It is most important that this should not be made worse by abdominal distension. For this reason any epigastric discomfort indicates the stomach-tube—not for lavage but simply to empty the viscus of gas and mucus. This measure often gives great relief. It is also important to be sure that the patient is not only passing urine but is emptying the bladder, and in bulky subjects this can only be ascertained by the use of the catheter. Gas in the intestines should not be allowed to accumulate, and it is wise to pass a flatus tube systematically every 4 or 6 hours. If, in spite of these measures, abdominal distension persists it should be treated by repeated small doses of strychnine, gr. $\frac{1}{40}$ every four hours, and the occasional use of pituitary extract. A simple glycerine enema will often result in the passage of a large volume of flatus. The same object may be

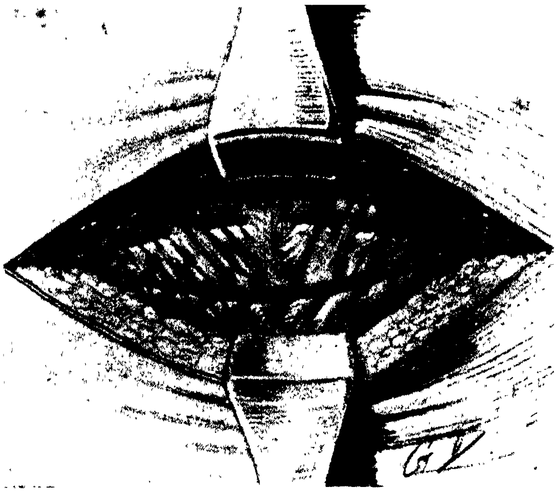

Fig. 529.—Radical cure of umbilical hernia by overlapping : sutures tied.
The suture for the edge of the fascial flap should have been interrupted.

assisted by inhalation of 90 per cent. oxygen which may be continued for 12 hours.

The infantile type.—The umbilical hernia of infants may sometimes be cured by keeping the protrusion *continuously* reduced for three months by a pad fixed with adhesive. After two years of age this method is most unlikely to be successful and, since the condition is often the forerunner of the troublesome adult hernia, radical cure is recommended.

Technique.—In order that the child may not be conspicuously different from its playfellows, the umbilical cicatrix should be preserved. For that purpose a curved incision is made either at its side or below it, and a small flap is turned aside with the scar, exposing the underlying sac. In this step the sac may be opened, but this is of no moment. The sac is isolated, its neck exposed and ligatured and the sac removed. The aperture in the parietes may sometimes be closed by a purse-string suture, or its edges merely drawn together, or it may be overlapped as in the Mayo method. Any plan which closes the gap seems to be efficient in children. The skin flap is then turned back into position and carefully sutured. The child may be allowed up and about as soon as sound healing has taken place.

Exomphalos or amniotic hernia.—In this condition there is arrest of intra-uterine development, and the intestines are not withdrawn into the abdomen. The large hernia-like swelling has for covering immature tissue without proper blood supply. If this condition does not rapidly recover soon after birth, operation should be carried out without delay. The membrane forming the summit must be excised, but every particle of skin is preserved and the incision surrounding the swelling must closely follow the skin margin. Some of the abdominal contents will be adherent to the inner surface of the sac but can usually be safely separated by the finger, assisted by gauze stripping. The skin edges are turned back to a sufficient extent to expose the aponeurosis of the abdominal wall. The edges of the gap are then approximated by interrupted sutures of stout catgut, as there is usually considerable tension. A series of silkworm-gut sutures is also passed through the skin and the parietes. These are run through fine rubber tubes to diminish the risk of cutting into the skin. Some few intermediate stitches draw the skin edges into accurate apposition. Further to diminish the considerable tension the wound is supported by strips of elastoplast. The tension silkworm sutures are not removed until after 10 or 14 days. By that time they may be nearly buried in the tissues and it may be necessary to administer an anæsthetic. Although the condition is a serious one, several cases successfully treated by operation are on record.*

Results.—Unlike inguinal and femoral hernias, where the mortality of the radical cure is very small, there is an appreciable risk to life in umbilical herniotomies, even in non-strangulated cases. This is due to the fact that the patients are generally unsuitable from the surgical standpoint, often being subject to bronchitis or renal insufficiency with dilated heart and high arterial tension. Thus, McGlannan reports an immediate mortality of 3 per cent., increased in strangulated cases to nearly 50 per cent. The St. Bartholomew's Hospital figures for the six years 1910–15 report 79 cases with one death, increased to 16 deaths in 31 strangulated cases (about 50 per cent.). To the end of 1928 Grey Turner had 121 radical cures with 2 deaths, a mortality of 1·65 per cent., but in 36 strangulated cases there were 13 deaths, a mortality of 36·11 per cent.

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* Rogers, *Brit. Journ. Surg.*, No. 113, 1941, xxix, 37. Ley, *ibid.*, No. 118, 1942, xxx, 168.

Figures of any value cannot be given for recurrences, owing to the different methods employed, and the varying conditions found at operation. Mayo reports 75 cases treated by his method, with 1 partial recurrence ; Coley and Hoguet* report 334 cases in adults with no recurrences. Such a degree of success is contrary to general experience and the surgeon naturally looks for some explanation. Sufferers from this variety of hernia are often so stout that a considerable recurrence may be so completely concealed in the subcutaneous fat that the patient may be unaware of it. Unless such patients are examined by an experienced person, recurrences may be undetected. In an unselected series personally operated upon, mostly by the Mayo method and examined by myself, I found 33 per cent. of recurrences. In 57 cases Wakeley had 22·2 per cent. recurrence.

OBTURATOR HERNIA

This hernia, though very rare, occurs with sufficient frequency to justify a short description of its peculiarities and the technique of treatment. In the majority of cases it is only discovered when laparotomy has been done for intestinal obstruction. The local signs are indefinite, and may be absent altogether. In a well-marked case there should be a swelling, which may be only a diffuse fullness, in the upper adductor region to the inner side of the femoral vessels. There may be tenderness on pressure over the upper and inner part of Scarpa's triangle, and if the pain radiates to the knee (Romberg's sign) the picture is complete ; but it is unusual to meet such a combination of signs. The patients are usually elderly wasted women who present symptoms and signs of small intestinal obstruction without any feature to indicate the cause.

Anatomy.—Three varieties are described : (1) The usual type, where the sac occupies the obturator canal, in front of and to the inner side of the obturator artery and nerve, and lying on the obturator externus muscle covered by the pectineus. (2) The hernia separates the fibres of the external obturator muscle so that it lies under cover of the pectineus with a muscular collar round the neck of the sac. (3) It separates the layers of the obturator membrane, burrowing from above downwards, so that it is covered not only by the pectineus but also by the obturator externus.

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* *Ann. Surg.*, Sept., 1918, lxvii, 263.

It must be remembered that the position of the obturator artery is not constant, and that there is always some risk of hæmorrhage in freeing the neck of the sac.

Operation through Scarpa's triangle.—The Trendelenburg position may be advantageous. The thigh is flexed and abducted. A vertical incision of adequate length is made parallel with and at least 1 in. to the inner side of the femoral vessels, beginning just below the spine of the pubis. The interval between the adductor longus on the inner side and the pectineus on the outer side is sought, and the muscles are separated and well retracted. A thorough retraction of the pectineus outwards, aided if necessary by cutting some of the muscle, will expose the sac. The neck should be thoroughly cleared, and the exact position of the obturator vessels ascertained. The edge of the constricting ring is defined, and an attempt made to stretch rather than to incise it. The sac is then opened, the greatest care being taken to catch any fluid that may be present, for fear of infecting this deep wound. The contents are now reduced ; if, as is possible, the hernia is strangulated, the loop is drawn down and the site of constriction scrutinized. If any treatment of the intestine is necessary, it is best at this stage to open the abdomen with the patient in the high Trendelenburg position, to withdraw the loop of intestine from the abdomen and to do what is required outside the abdomen. The attempt to close the opening is more likely to be successful from within, and is free from risk of injury to the vessels. If the hernia is not strangulated, or if the gut can safely be returned, the sac, after being emptied, is transfixed, tied, and cut off as high up as possible. It is doubtful whether the closure of the canal can be achieved, but the deeper part of the wound should be obliterated with catgut sutures and drainage provided.

Operation through the abdomen.—As a rule this hernia is only discovered incidentally during the course of operation for intestinal obstruction in thin elderly women. In these circumstances the small intestine will be found apparently attached to the pelvic wall just below the front part of the brim. Inspection, which is easier in the Trendelenburg posture, will reveal the true condition. As a rule slight traction on the bowel will be enough to withdraw it into the abdomen but occasionally it may be necessary to stretch or to incise the neck of the sac before the bowel can be released. Incision of the neck should be made directly forwards. The bowel must be dealt with as its condition indicates (*see* p. 1100). After the intestine has been released and dealt with, the sac may be withdrawn into the abdomen and ligatured off. This may be done by passing a strong artery forceps to the bottom of the sac, seizing a portion and withdrawing it through the neck, i.e. inverting the sac into the peritoneal cavity. (This is a method which may be employed for femoral or even small inguinal hernias when they are discovered during the course of an abdominal operation.) If this is not possible, the orifice must be closed by a purse-string or other suture.

Epigastric hernia.—This variety is usually quite small and often turns out to be an extra-peritoneal lipoma herniated through an aperture in the linea alba. To make a satisfactory repair it is best to incise the aponeurosis in the middle line up to the edges of the apparent sac both above and below it. The sac is carefully isolated and should always be opened before ligature, as it may contain omentum or, very rarely, a knuckle of stomach or colon. The contents are seldom adherent. The sac is excised and the parietes repaired in layers. In this hernia the circumstances often demand an exploration of the upper abdomen, and this may conveniently be combined with the repair.

SCAR OR INCISIONAL HERNIA

The following are amongst the commonest causes of this type of hernia :—(1) prolonged drainage of an intra-abdominal abscess ; (2) suppuration of the wound with retraction of the edges and healing by granulation ; (3) separation in the muscle-layer suture-line ; (4) injury to the muscles or their nerve supply ; (5) incessant cough, and (6) persistent abdominal distension after operation. The first cause is by far the most common, and may well be considered together with the second, since it is almost the rule for suppuration of the wound to occur if prolonged drainage is necessary. Occasionally a weak scar is seen as the result of stitch-abscesses. It sometimes follows cholecystostomy when the gall-bladder has been drained for a long time, or suprapubic prostatectomy or colostomy, although in neither of these cases does suppuration of the abdominal wall usually occur.

Scar hernias of the third group are by no means well understood. It is recognized that from time to time cases occur where, for some unknown reason, there is a spontaneous bursting open of the wound, sometimes the whole incision giving way with intestinal protrusion, but more usually the peritoneal and muscle suture-lines give way first, and the skin subsequently. In some cases the skin does not give way, and a scar hernia quietly establishes itself.

In the fourth group the rectus abdominis is generally affected, the nerve supply being injured by long incisions in the linea semilunaris, or in muscle-splitting operations as in some vertical approaches to the gall-bladder through the rectus muscle.

Prolonged drainage of an intra-abdominal abscess is often accompanied by sloughing of some structures of the abdominal wall, aponeurotic or muscular, or both. The chances of a scar hernia are in direct proportion to the length of time that drainage is maintained. Thus, Abel states that two weeks' drainage is followed by scar hernia in 40 per cent., three weeks' in 50 per cent., four weeks' in 65 per cent., and over four weeks' in 80 per cent. He also maintains that a scar hernia is twice as likely to follow single-layer suturing as multiple-layer suturing.

Characters of a scar hernia.—With the exception of those cases in the third and fourth groups where suppuration has not occurred, the scar always shows evidence of slow healing. It is irregular, wide, puckered, and perhaps discoloured. The covering is thin, generally consisting of atrophied skin without fat or superficial fascia. The edges of the opening in the abdominal wall can be defined, and frequently the hernia can apparently be easily reduced, or even reduces itself when the patient lies down. This, however, is seldom the case, for most scar hernias are more or less irreducible—that is, there are adhesions between some part of the contents and the sac, or the peritoneum at or near the neck of the sac. There is, also, always some loss of substance in the abdominal wall, generally aponeurotic, sometimes muscular. The hernia always contains omentum, generally large intestine, and sometimes small intestine. There is a resemblance between scar hernia and umbilical hernia in that many of these patients are fat and are poor surgical risks, so that it is advisable to prepare them for operation very much on the same lines.

Technique.—The whole of the scar in the skin must be widely excised by an elliptical incision which is deepened until the aponeurosis is reached ; this must be carefully cleared of fat, the dissection proceeding towards the margin of the hernial opening until the edge is identified. If the opening is a small one, and there has been no great loss of tissue, an anatomical restoration of the abdominal wall should be attempted. A spindle-shaped incision is made through the aponeurosis, the ellipse skirting the opening as closely as possible, and the ends being prolonged as far each way as may be necessary. A free incision of the aponeurosis makes the subsequent steps all the easier. This incision is deepened at a point farthest away from the hernial opening, and the peritoneal cavity opened, as there is less risk of adherent viscera at the periphery. The peritoneum is opened in the line of the incision, the hernia in the unopened sac is lifted up, and the general peritoneal cavity packed off with pads around the pedicle.

The sac is opened at the neck and emptied by blunt dissection, being turned inside out if necessary to facilitate the freeing of adhesions. The sac is then cut away, the pads are removed, the hernial contents replaced in the abdomen, and the peritoneum sutured.

The aponeurosis is now dissected back for a sufficient distance to expose the muscle-layer. What the muscle-layer may be depends on the situation of the hernia ; for instance, it may be the rectus muscle on the inner side and the internal oblique on the outer side in appendix cases (following Battle's incision), or the recti abdominis in epigastric cases. The whole of the muscular boundary of the aperture must be exposed and if the edges are attenuated into a sheet of fibrous tissue this must be cut away until the muscular fibres are exposed. All bleeding is arrested, and the muscle sutured with interrupted catgut sutures. The aponeurotic layer is now sutured edge to edge or preferably overlapped, and the skin sutured without drainage.

A different method should be adopted if the opening is very large or if there has been much loss of tissue or if the edges cannot be approximated without tension. In such circumstances the attempt to effect an anatomical restoration of the abdominal wall will almost certainly be a failure, and it is much better not to try.

The steps are the same as those of the preceding operation, up to the point where the hernial contents are replaced in the abdomen. The peritoneum is not sutured, and no attempt is made to separate the abdominal wall into layers. It may then be possible to overlap the sheet of fibrous tissue which forms the margin of the opening. This is carried out in much the same way as in the Mayo method for umbilical hernia. Some surgeons consider that the fibrous tissue which has replaced the muscles will not form a reliable barrier, and prefer to cut it away until normal-looking muscle is reached. When this has been done it may be impossible to get the freshened muscle edges together and it is necessary to approximate them as nearly as possible with stout catgut sutures and then to bridge any resulting gap with fascial strips crossed after the fashion of a shoe lace. When this is accomplished an attempt must be made to get the external oblique into apposition, supporting catgut sutures with fascial strips. Sometimes a free patch cut from the fascia lata may be used to cover a large aperture with rigid edges that cannot be approximated, but this method has not proved very reliable.

Two other plans are available. One is to use a silver wire filigree, the other is to swing in a large muscle flap. The filigree is laid on the muscle edges and fixed with a few points of suture, the external oblique being drawn together over it as far as possible, and the subcutaneous tissue as well as the skin being carefully approximated.

The use of muscle as a flap has most often been employed for hernia situated in the lower lateral part of the abdominal wall. In the upper abdomen pedicled flaps of fascia and muscle have been turned down from the pectoral region. Kenneth Mackenzie has used this plan with success.* A patient presented a very large traumatic hernia in the lower abdomen and the tensor fasciæ femoris seemed to be the most suitable muscle because: " Its upper attachment to the spine of the ilium is of small size, and this allows of the easy swinging of the muscle. The nervous and vascular supply enter the muscle very high up, and nerve and vessels, placed near the centre of swinging, are scarcely stretched when the muscle is in its new position. Lastly, the loss of this muscle is of small account to the limb." After the sac of the hernia has been dealt with, a vertical incision is made down the anterolateral border of the thigh so that the whole of the tensor muscle is exposed. The origin of the muscle from the ilium is left intact, but the fascia lata is divided about 1½ in. all round the muscle so that the latter is supplied with a fascial fringe. After being thoroughly freed in the thigh it is swung round into the gap in the parietes. The margins of fascia surrounding the muscle may overlap the margins of the gap or may just fit into it. (Fig. 530.) In either case they are to be fixed to the margins of the hernial opening with catgut or fascial sutures and the skin and subcutaneous tissues are carefully sutured over all. The details of the method are also discussed and fully illustrated in a paper by Owen H. Wangensteen.* This surgeon has also employed the method in certain cases of inguinal and femoral hernia and with encouraging results. In all operations this type great care must be taken to arrest all hæmorrhage and to protect the large wound from risk of infection. Interventions for large scar hernias rank among the biggest in surgery and may be attended with considerable shock, and patients must be carefully watched and cared for during the ordeal.

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* *Brit. Journ. Surg.*, 1924, xii, No. 45, 28.

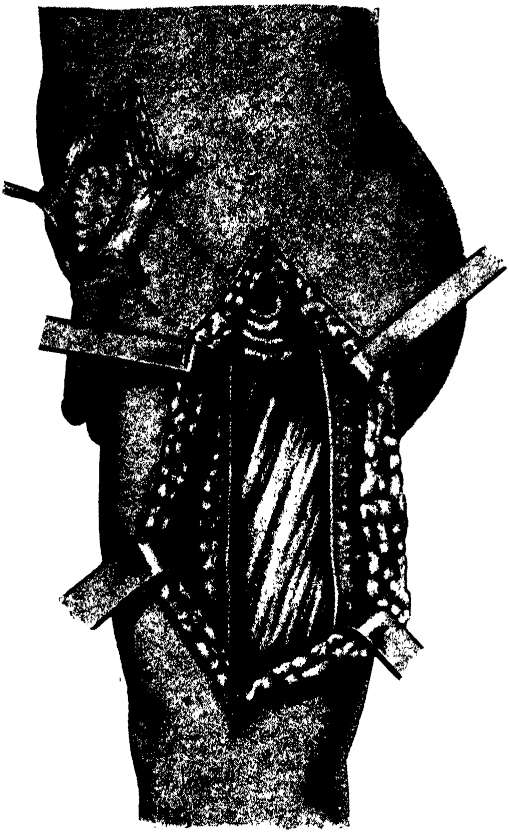

Fig. 530.—Repair of recurrent inguinal hernia by transplantation of tensor fasciæ femoris muscle.

Operations for recurrent inguinal hernia.—The surgeon must exercise great care in exposing the parts as the anatomy is so much altered by the previous attempts at repair. When the veins of the cord have been removed at the first operation the difficulties are increased. In these circumstances what remains of the cord is often in jeopardy and the vas may easily be torn or divided. No rules can be given to make this operation easy, but it is essential to have a sufficient exposure and to endeavour at an early stage to identify some anatomical structure which will serve as a guide.* It is in dealing with these cases that Gallie's method of repair (Figs. 531, 532) is so valuable.

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* *Surg. Gyn. and Obst.*, Nov., 1934, lix, 766.

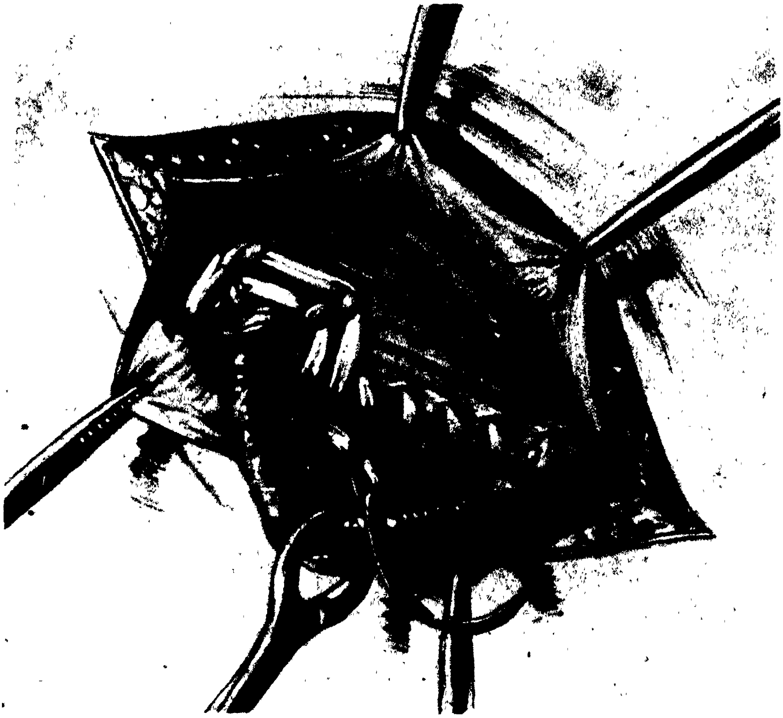

Fig. 531.—The repair of recurrent inguinal hernia by Gallie's method. The first layer.

In femoral and the different varieties of ventral hernia, there are not such special difficulties, but the sac may be deviated and loculated and the structures bounding the openings to be closed are often very attenuated. The surgeon must constantly bear in mind the importance of adequate exposure by ample incisions which need not necessarily follow those originally employed.

LUMBAR HERNIA

This usually follows an operation for exposure of the kidney, though it may be congenital and through Petit's triangle. For radical cure it is first essential to expose the sac with its boundaries. As a rule such a sac should be carefully isolated and removed but a shallow (not very large or prominent) sac may be inverted towards the abdomen without being opened. The sac may contain the descending colon, which may be extensively adherent to its wall, and much care must be exercised lest it be torn. The boundaries of the hernial aperture will be the muscles of the area, and these, if they have not been too much damaged by suppuration, may be defined and sutured layer by layer with stout catgut. The most superficial of the muscles may be like a sheet of scar tissue and in that case may often be overlapped. Whenever there is tension, fascial sutures should be used in addition to catgut. But in some cases either the whole of the involved area or some part of it has firm resisting edges which cannot be drawn together. In these circumstances the gap must either be closed by interlacing it with fascial strands or by using a filigree.

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* William Patrick, *Brit. Journ. Surg.*, No. 123, 1944, xxxi, 231

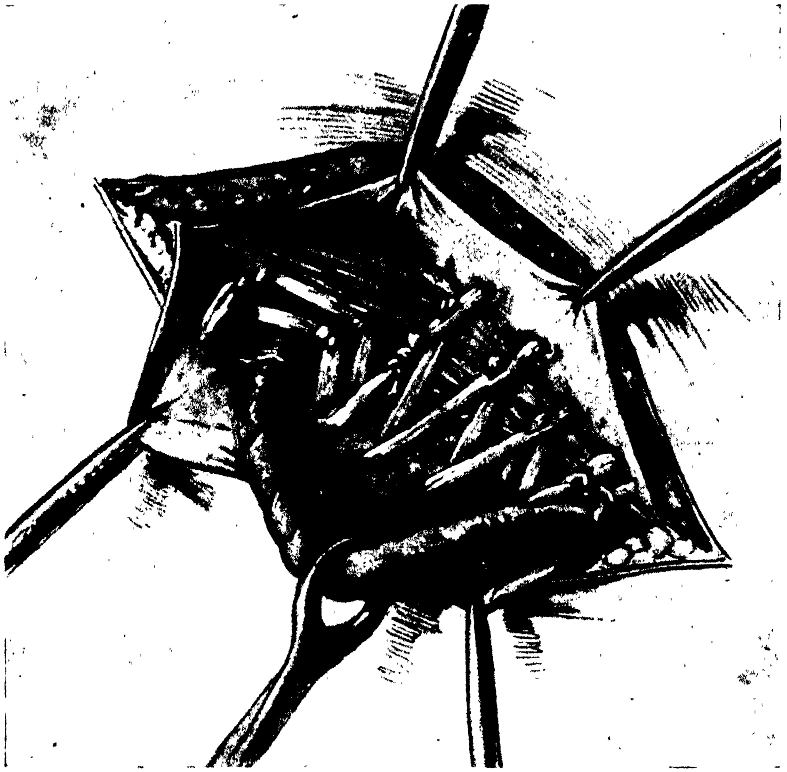

Fig. 532.—Gallie's operation completed by interlacing fascial sutures.

SUPRAPUBIC HERNIA

This variety either follows drainage of the pelvis by the abdominal route or suprapubic cystotomy. It may be possible to deal with it on the general principles already described but when the lower margin is formed by the pubic bones it is difficult to make a satisfactory closure in this way. In the latter circumstances Nuttall * has suggested that the recti muscles should be divided just above the pubes, or detached from that bone, and should then be crossed over the hernial site (of course after excision of the sac) and sutured in this new position. (Fig. 533.) The later results have been satisfactory.

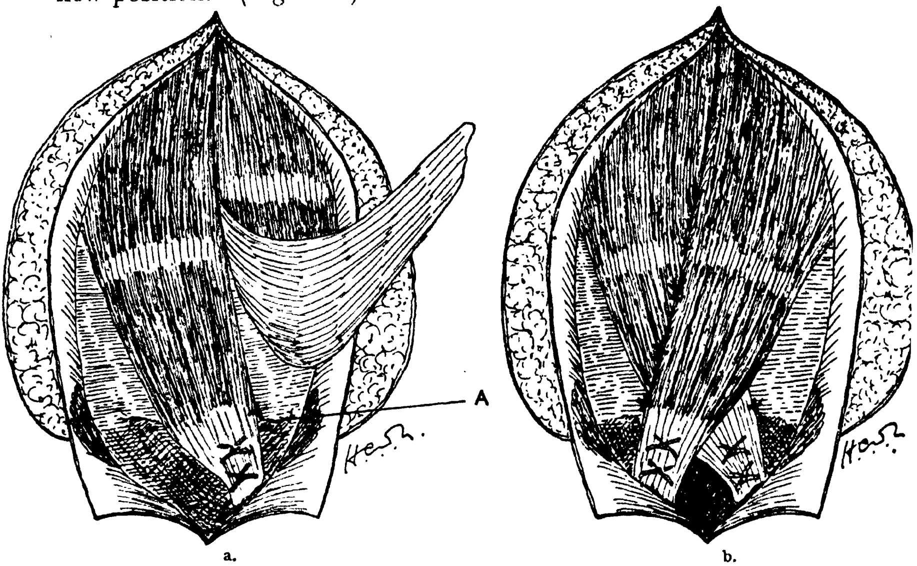

Fig: 533.—Crossing the recti for cure of suprapubic hernia. (a) Right rectus. (b) Left rectus sutured to pubes of opposite side. (A) upper edge of symphysis pubis.

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VERY LARGE HERNIAS

Inguinal herniæ which reach almost to the level of the knees are seldom seen nowadays, but there are some few examples of very large ruptures which are often recurrences following operations for inguinal hernia or are of the incisional type. In such cases the question usually arises of the wisdom of attempting any operation and each case must be decided on its merits. One of the first questions is the capacity of the abdominal cavity to contain the added contents of the hernia without embarrassment to respiration and general comfort. When the abdomen is naturally lax and the hernia readily reducible the question is easily answered, but in other circumstances the surgeon must make an estimate of the probability. A hernia which appears to be irreducible will often recede when the patient is kept in the Trendelenburg posture for a day or two, or complete reduction may then be brought about by manipulation. If the patient is comfortable after reduction and is neither short of breath nor the abdomen unusually tense, the conditions for operation are favourable. Even in cases of strangulation these considerations govern the management

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* *Brit. Journ. Surg.*, 1937, No. 98, xxv, 344.

of the case. If, for instance, it seems impossible for the abdomen to contain the contents of the hernia with comfort, then the surgeon must be content to open the sac, deal with the obstructing or strangulating agent, and merely repair the sac without attempting either to reduce the contents into the abdomen or to carry out radical cure.

Chronic cough and increasing uncontrollable obesity are both very serious drawbacks to successful intervention. Before interference the general condition of the patient must be carefully overlooked and especially the questions of glycosuria and renal function. Naturally the state of the cardio-vascular system is very important, but a high blood pressure is not in itself a contra-indication to operation.

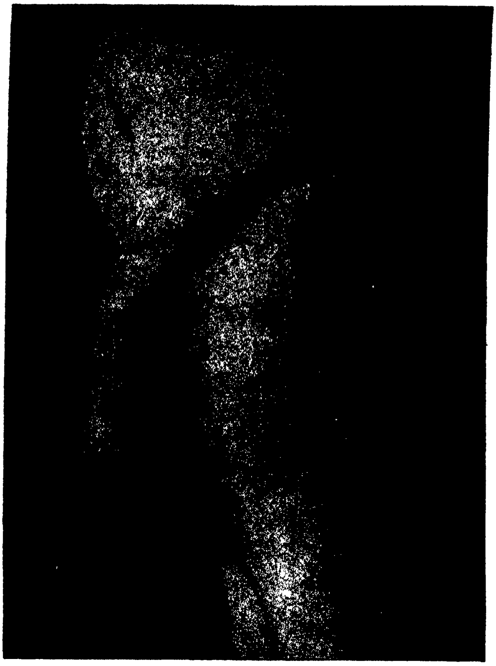
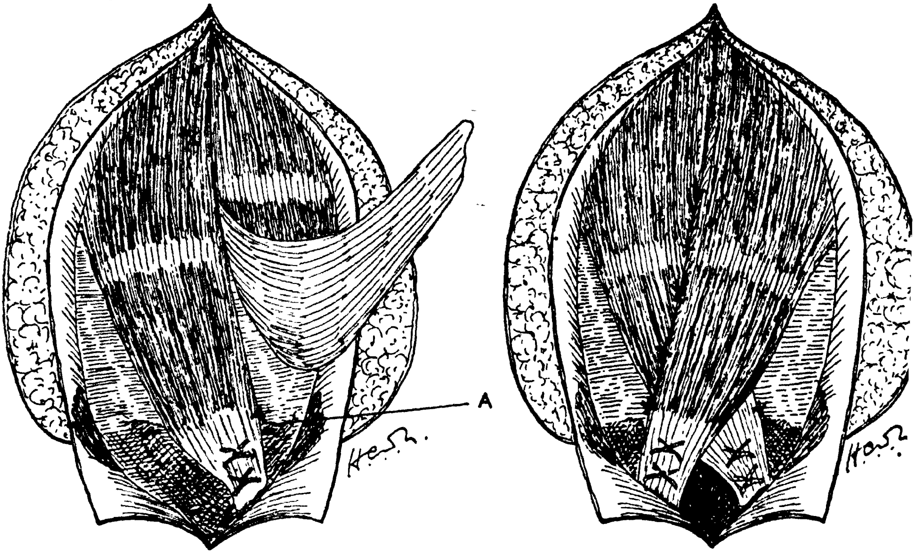


Fig. 534—Large inguinal hernia.

When it has been decided to operate, some little time must be devoted to preparation. In many of these patients the mere size of the hernia has seriously interfered with their getting about, and careful regulated walking exercise is a valuable preparation. Regulation of the diet to diminish gaseous distension and the care of the bowels are both important. Free bowel movements must be secured. Careful preparation of the skin is also essential, and one or two days are often required for its thorough cleansing. The question of anæsthesia deserves consideration but, as fascial strips have often to be cut, the on the general principles already described but when the lower margin is formed by the pubic bones it is difficult to make a satisfactory closure in this way. In the latter circumstances Nuttall * has suggested that the recti muscles should be divided just above the pubes, or detached from that bone, and should then be crossed over the hernial site (of course after excision of the sac) and sutured in this new position. (Fig. 533.) The later results have been satisfactory.



a. b.

Fig: 533.—Crossing the recti for cure of suprapubic hernia. (a) Right rectus. (b) Left rectus sutured to pubes of opposite side. (A) upper edge of symphysis pubis.

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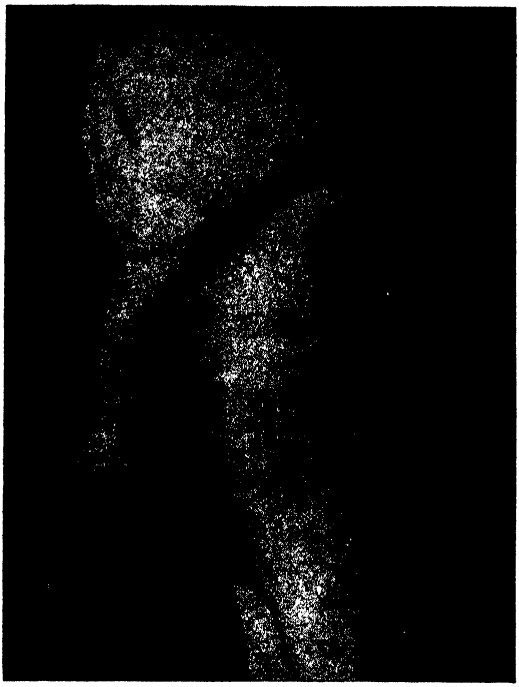

Fig. 534—Large inguinal hernia.

When it has been decided to operate, some little time must be devoted to preparation. In many of these patients the mere size of the hernia has seriously interfered with their getting about, and careful regulated walking exercise is a valuable preparation. Regulation of the diet to diminish gaseous distension and the care of the bowels are both important. Free bowel movements must be secured. Careful preparation of the skin is also essential, and one or two days are often required for its thorough cleansing. The question of anæsthesia deserves consideration but, as fascial strips have often to be cut, the choice will usually lie between spinal or inhalation anæsthesia. The use of local anæsthesia occupies much time, especially when strips have to be cut from the thigh.

In the actual operation the first step must always be the proper exposure, isolation and removal of the sac, and this will require a large parietal incision. The closure of the abdominal wall may be unexpectedly easy, and catgut sutures may secure good apposition without tension. But difficulties in closure are frequently met and it is then that the fascial sutures of Gallie are so useful. In those few cases where the gap is so large that the strips make but a feeble lattice-work over the huge aperture, or where fascial sutures have not been a success in a previous operation, at least two other methods may be resorted to: (*a*) the wire filigree (p. 1049) and (*b*) muscle transplantation (p. 1090).

In these operations it is essential that asepsis and hæmostasis should be faultless, but this is often difficult because of the extent of the wound and the time occupied in the operation. These interventions may severely tax not only the resource but also the patience of the surgeon, and some technical laxity may creep in during the later stages. During the operation it is wise to take great care to cover, with large gauze swabs, such part of the wound as is not actually required at the moment. In the after-care abdominal distension must be carefully avoided or promptly treated.

American surgeons have tackled the problem of the enormous umbilical hernia by actually excising large amounts of the parietal tissues with the sac and, if necessary, the whole of the omentum and the greater part of the colon.

STRANGULATED HERNIA

It should be recognized that anything wrong with a hernia demands operative interference, which is far safer than the old temporizing measures which were adopted when surgeons diagnosed conditions like incarceration and inflammation rather than strangulation. The surgeon may find that a hernia has been reduced *en masse* by attempts at taxis and this may be done by the patient himself; "auto-reduction *en masse.*" In conditions of doubt exploration of the hernia is much safer than any other plan.

In the presence of vomiting all hernias of moderate size should certainly be operated upon, using local infiltration anæsthesia. In large hernias, and especially the umbilical variety, local anæsthesia may occupy a great deal of time, but often the greater part of the operation can be completed under this method, only a small quantity of general anæsthetic being necessary in the later stages. If the blood pressure is not much lowered spinal anæsthesia can safely be employed. Whenever a general anæsthetic must be used, the stomach should be emptied by tube immediately before, as there is very grave risk that intestinal contents may be regurgitated during the operation and may be aspirated into the lungs. For this reason it is a good plan to leave the tube *in situ* while the operation is in progress so that the stomach can be aspirated from time to time. The steps of the operation for strangulated hernia are always the same: (1) parietal incision and exposure of the sac; (2) opening the sac; (3) inspection of the contents; (4) dealing with the stricture or strangulating agent; (5) disposal of the contents, and (6) completion of the operation.

In inguinal and femoral hernias the strangulating agent is nearly always the peritoneal neck of the sac, and this can usually be drawn down sufficiently to be divided either with scissors or hernia knife under the guidance of the eye. In femoral hernia, Gimbernat's ligament may be a contributory factor in strangulation, but should not be hastily divided as this step weakens the hernial region very much. After the sac has been opened, forceps are applied to its cut margin, and, with a little care and the aid of dissecting forceps, the parts outside the neck can nearly always be loosened sufficiently to enable the sac to be drawn down so that the neck can be seen and divided under the guidance of the eye, as in inguinal hernia. Sometimes it is impossible to pull down a femoral sac in this way. In these circumstances the surgeon should introduce a finger into the sac and, reaching the strangulating agent, he will often find that he can gradually insinuate the finger through the neck by the side of the intestine and can dilate the orifice sufficiently to break down its resistance completely and enable the gut to be easily drawn down for inspection. If neither of these methods is possible, then it is necessary to divide the neck of the sac blindly. This is done by introducing a hernia director between the bowel and the neck on the inner side. A hernia knife is then carried up the groove of the director and the neck of the sac divided. If this is done it will nearly always be found that the constriction disappears and that it is unnecessary to divide Gimbernat's ligament, but in some cases this must be divided before reduction can be effected. It should be cut from outside and not through the sac. In umbilical hernia the strangulation may either be at the neck of the sac or inside the sac, some of the contents being caught in a pocket or being strangulated by bands or adhesions. In these circumstances it is easier to see the exact cause of the strangulation, but it may be difficult to disentangle the parts and to free the contents completely.

When it has been thought safe to return the gut, the operation can usually be completed by carrying out the radical cure suitable for the region involved. But in old and very feeble subjects, or when the surgeon is working under improvised conditions or is inexperienced, the question will arise how to deal with the sac and how to finish the operation after the strangulation has been relieved. In these circumstances the tyro need have no hesitation in leaving the sac *in situ* and simply packing it and the wound with gauze. This is the simplest method of finishing the operation, and it is all that is necessary for life-saving purposes. Any further interference for the radical cure of the hernia can be deferred to a later date, weeks or months after the operation, or in fact in old and enfeebled people and especially with femoral or small inguinal hernias, may often be dispensed with altogether, as the hernial region will heal by granulation and possibly not give much further trouble. Some cases of strangulated umbilical hernia are so enormous that it is courting disaster to attempt radical cure after strangulation has been relieved, and it is much wiser merely to stitch up the hernial sac and to leave it *in situ* without any attempt at its removal, i.e. to restore the hernia to its original state after dealing with the strangulation. Many a life would be spared if this step was adopted. Surgeons should recognize that the life-saving measure is the operation of " herniotomy " which does not presuppose the performance of " radical cure."

In many cases of femoral hernia in feeble people the gut is extensively damaged though not obviously beyond recovery. In these circumstances it may be reduced just within the hernial opening, a tube being brought to the surface through the incision. The gut very rapidly becomes adherent in its new site, and quite often a case recovers without any complication or with the formation of only a temporary fistula. No rules can be given which will decide when this method should be adopted or when it is necessary to resect or make a formal fæcal fistula. Probably one method is as successful as the other, but with either the mortality is not less than 50 per cent.

When the hernial sac contains only a small knuckle of intestine (Richter's hernia) it is absolutely essential that the bowel should be brought down into the sac for thorough inspection. Sometimes the little button which has been nipped is obviously quite recoverable, but in many cases it is of doubtful vitality. In the latter circumstances it may be of such a small size that it can safely be inverted into the intestine and over-sewn by the Lembert method. It is only when it involves an area greater than one-third of the circumference of the bowel that in doubtful cases a formal resection should be carried out.

It is in these cases that the gut often slips back into the abdomen before it can be pulled down. It is safer to inspect the gut than to leave the matter to chance, and the surgeon should enlarge the orifice of the sac and draw down the intestine for careful examination. The intestine which has occupied the sac remains in the vicinity of its abdominal orifice for some time and can nearly always be grasped with a pair of sponge forceps and brought down so that any doubtful areas can be dealt with. If this is not done, then in a certain proportion of cases the gut will subsequently give way in the abdomen and the patient will die of peritonitis.

In some cases of strangulation it is found, on opening the sac, either that the gut is gangrenous or that its vitality is so doubtful that its return to the abdomen is inadvisable. The whole loop may be gangrenous, including the mesentery, or there may be patches of gangrene, chiefly on the antimesenteric border, or gangrene may have occurred only at the line of constriction. This last possibility makes it essential, after the constriction is divided and before the gut is reduced, to draw the loop down so that the line of constriction can be inspected. (Fig. 535.) The appearance of a gangrenous piece of intestine—the flaccid collapsed loop with its lustreless discoloured (black, grey, or green) surface, the pulseless mesentery, and the sanious, blood-stained and perhaps offensive fluid in the sac—is sufficiently characteristic to make error unlikely. But in the lesser degrees of strangulation it is difficult at times to be absolutely certain. In such a case the suspected loop should be wrapped up for two or three minutes in hot pads after the constriction has been released, when its viability will be proved if its colour improves. It must not be accepted that recovery of the loop is certain because one can see pulsation in the mesentery. It is a common mistake to look upon gut as beyond hope of recovery when it is merely congested and œdematous, with some haemorrhage into its wall. If an area of doubtful viability occurs all round the gut or involves the gut right up to the mesentery, it is an indication for resection, but if it only involves a small part of the convexity or a small area where the gut has actually been compressed by the strangulating agent, then it may be dealt with by being tucked in and oversewn Lembert-fashion. With experience the surgeon encounters ever fewer cases in which there is doubt, but it is a good working rule that if one cannot be sure that the loop is viable, it should be treated as if it were not.

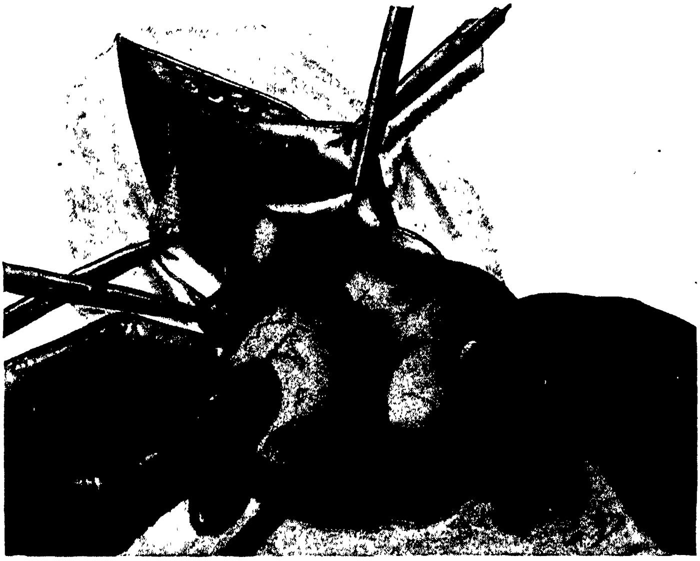

Fig. 535.—The points at which gangrene may occur in strangulated hernias, viz. either on the summit of the involved loop or at the point of constriction.

If it is decided that the gut must not be returned to the abdomen, what is the best thing to do ? It depends on many considerations—upon the condition of the patient, always more or less toxæmic and exhausted by pain, sleeplessness, and vomiting ; upon the type of hernia ; upon the length of time already occupied by the operation ; upon the surroundings (for these urgent operations are not always undertaken in a modern operating theatre with perfect light and skilled assistance), and upon the capacity of the surgeon for rapid intestinal work. In general terms it may be said that the object of the operation is to save the life of a patient faced with very grave emergency, and if any elaboration of the absolute minimum is likely to prejudice the chance of recovery, it must not be entertained for a moment. It is not suggested that the routine operation in gangrenous hernia should be the formation of a fæcal fistula, but to establish such a fistula in the very bad cases may be safer than to carry out resection. It must be remembered that the mortality of all strangulated hernias is around 20 per cent., and if gangrenous hernias only are considered the mortality is nearer 60 per cent.

Many methods of treating gangrenous intestine have been suggested, and local treatment of gangrenous patches by excision, infolding, or invagination may sometimes be safely used if the areas are small and well-defined. When this is not possible, there are three other courses : (1) In *doubtful cases*, release of the constriction but retention of the loop in the sac. (2) In *cases of definite gangrene with the patient in good condition*, resection and anastomosis. (3) In *cases of gangrene with condition of patient or surroundings less favourable*, making an artificial anus.

Technique. (1) **Retention of loop in sac.**—Wash the loop and the interior of the sac with saline solution. If only a small loop can be withdrawn, it should be fixed at or near the neck of the sac by a few catgut sutures between the gut and the sac. If there is much tension, support will be obtained by passing a colostomy rod or length of rubber tubing through the mesentery. The loop of bowel should be covered with perforated protective, and dressed with gauze wrung out in hot saline and frequently changed. If the gut gives way, it will not be until the peritoneal cavity is safely sealed off, and an artificial anus will result, which can be dealt with when the time arrives. If the gut recovers, the intestine will gradually reduce itself, or can be reduced by a planned operation, devised to remove the sac and effect a radical cure.

(2) **Resection and anastomosis.**—Wash the loop and interior of the sac with saline solution. Wrap the gangrenous loop in moist pads and shut off the area of operation with strips of gauze clipped on to the edge of the incision. It is essential to make the section of the bowel through healthy tissue. For this purpose several inches of intestine above the gangrenous area and two or more inches below will have to be sacrificed. It is not necessary to remove a large area of the mesentery but it is probably safer to make the section through the vessels above the point at which they are thrombosed. As a rule, the anastomosis should be made by the end-to-end method with direct suture as described in the section on Enterectomy (Vol. I, p. 908).

In some cases it will be found that the upper (proximal) end is so much larger in diameter than the lower (distal) end that end-to-end anastomosis seems unsuitable. Much may be done, however, by an oblique section of the lower end to increase its lumen, or an incision may be made along the antimesenteric border at right angles to the open end of the smaller bowel. Generally speaking, it is safe to pucker up the larger end by placing the stitches more widely apart than in the smaller end, in cases where the disproportion is not too marked. The alternative is to close both ends and do a lateral anastomosis, but this is rarely necessary. End-to-side anastomosis is not advised.

(3) **Making an artificial anus.**—In the more desperate cases, where the condition of the patient not only forbids a long operation, but when decompression of the intestine is imperative, the formation of an artificial anus is indicated. *In all cases the constriction must be relieved* as a first step, and the loop drawn down, so that the line of constriction can be inspected. This obviates the risk of perforation and extravasation within the abdomen, or inside the neck of the sac, as the result of ulceration at the stricture line. The simplest method of all is to attach the loop by a few sutures to the sac as near the neck as possible, incise the gut along its antimesenteric border, sew the cut edge to the sac or the skin at the line of incision, and make certain of adequate drainage by passing into the proximal loop a tube of the size of a 14 rubber catheter. If, however, a considerable length is gangrenous, this method would leave a mass of septic material which would take a long time to separate, and might well give rise to infection of the surrounding integument. In such a case it is well as a first step to suture the two limbs of the loop together above the portion to be resected, and also to the sac near the neck, to prevent the loop slipping back into the abdomen. The gangrenous portion is then cut away, and all bleeding carefully arrested. The ends may be left open or tubes may be tied in.

After-treatment of artificial anus.—The after-treatment of artificial anus presents many problems. In the first instance, as the result of toxæmic paresis of the intestine, the bowels may not function. In these circumstances the general remedies which are most valuable are, first, those relied upon for overcoming toxæmia, and especially flushing the tissues with water administered by the mouth or the rectum, or glucose saline injected into the muscles or intravenously, whichever route seems indicated. Secondly, the stimulation of the plain muscle of the intestine by hypodermic exhibition of strychnine in small doses frequently repeated, and by the use of specific excitants such as pituitary extract or acetylcholine or similar substances. The inhalation of 90 per cent. oxygen is sometimes effective. If these measures all fail, purgative remedies may be tried, and of these the best is calomel in quarter-grain doses repeated every half-hour until 3 gr. has been administered, assisted by the other measures which have been mentioned. Strong concentrated salines are also sometimes effective. Injections may be made locally into the exposed lumen of the bowel and various substances may be tried.

The next difficulty is the too-free escape of intestinal contents, especially when the opening happens to be high in the alimentary canal. In these circumstances it may be possible to conduct the contents from one loop to the other by a rubber tube, inserted temporarily, or the escaping contents may be collected and injected into the lower loop by a syringe, or may even be administered per rectum. The fluid and chloride loss may be temporarily renewed by the intravenous administration of normal saline. When the problem becomes serious, and despite all efforts the patient begins to lose ground, then some surgical interference is imperative. In these circumstances the simplest measures which will suffice should be first adopted. As a rule, it is necessary to open the abdomen well away from the site and to make an anastomosis between the loops of bowel going to the hernia. Such an anastomosis will probably not function satisfactorily unless the bowel between it and the hernia is interrupted either by division and inversion of the ends or by a thick encircling ligature of catgut buried by a few Lembert sutures. Once the normal intestinal current is restored, the patient may be expected to pick up rapidly, and the operation for the repair of the hernia and the removal of the gut in that situation can be undertaken with confidence in three or four weeks. In other cases in which the whole of the contents do not escape by the fistula, spontaneous closure may take place, or the fistula may be dealt with locally at the hernial site. This requires the separation of the intestines from the margins of the opening so that they can be drawn down for the purpose of repair. Quite often a formal resection may be necessary and in femoral hernia this is better conducted through an independent laparotomy incision about two inches above and parallel with Poupart's ligament.

Accidents in connection with the operation for strangulated hernia.— —Sometimes the neck of the sac has been torn during attempts at reduction or, more commonly, it has been rather too freely incised during division of the constriction. In either case the intestine may be reduced inadvertently through the rent into the cellular tissue, strangulation then persisting as the result of constriction by the margins of the rent. It is only necessary to mention this possibility to show the necessity of care to prevent it. After reduction of a hernia, either by taxis or by successful operation, the patient may suffer from a form of ileus which may prove fatal. This is to be treated by measures already detailed ; sometimes this condition has yielded to spinal anæsthesia. If all means fail to relieve, the abdomen must be opened and a lateral anastomosis made, short-circuiting the portion of bowel that has been in the sac, but it does not follow that even this will be successful, for the complication is a very serious one.

DIAPHRAGMATIC HERNIA

This variety of hernia, though not common, is less rare than is generally supposed. It consists of a protrusion into the chest of some abdominal viscus, in part or as a whole, and either with or without a peritoneal sac. When a sac is absent the contents may be adherent to the thoracic viscera. The condition may be traumatic or congenital. In the former variety the defect is generally in the dome of the diaphragm. The contents are variable but usually consist of portions of the stomach and colon, sometimes with coils of small intestine. In one of the congenital types the herniation takes place through the œsophageal foramen and is spoken of as " para-œsophageal " or " hiatus " hernia. This variety is sometimes associated with congenitally short œsophagus. In hiatus hernia some part of the stomach or even the whole viscus herniates into the thorax and may be accompanied by the left lobe of the liver.

The symptoms are usually digestive : pain, associated with a sense of extreme distension, aggravated by food and relieved by eructations or vomiting. Patients sometimes state that they are afraid to eat. Quite often gallstones are simulated and in a good many of the cases the biliary tract has been explored before the correct diagnosis is made. In some cases there is œsophageal obstruction which may closely simulate cardiospasm.

Indications for operation.—Diaphragmatic hernia is not in itself an indication for operative treatment as intervention is certainly not free from risk. When symptoms are troublesome and persistent, operation is recommended. It is advisable to interfere during the quiescent period and not to risk the development of an emergency. When X-ray investigation demonstrates small intestine in the hernia, operation should be advised, for strangulation is then likely to occur and is a very serious complication.

Technique of operation.—General anæsthesia is usually employed, for complete relaxation is essential. In cases of difficulty, regional may be combined with general anæsthesia by injecting the lower intercostal nerves on the left side just below the angles of the ribs. Complete relaxation of the diaphragm may be secured by blocking or crushing the phrenic nerve in the root of the neck.

The approach largely depends on the type and situation of the hernia and whether the contents are known to be reducible. In practice the abdominal route is usually employed and, in most cases, operation can be completed from below the diaphragm. A mid-line epigastric incision is most useful, but it should be carried right up into the sterno-costal angle. Some surgeons prefer an incision parallel with, and just below, the left costal margin. The reversed Trendelenburg posture is helpful and further exposure may be obtained by separating the left lobe of the liver from its diaphragmatic attachment and drawing it towards the right side. (Fig. 536.) If the aperture can be readily exposed the contents may be withdrawn into the abdomen without difficulty. In some cases, however, reduction may be very troublesome and this may be due to negative pressure or to adhesions. The former may be overcome by introducing a tube into the hernial sac by the side of the contents or by puncturing the pleura, There may be adhesions to the margins of the opening in the diaphragm, in which case they can be readily dealt with under the guidance of the eye, or the contents may be adherent within the sac

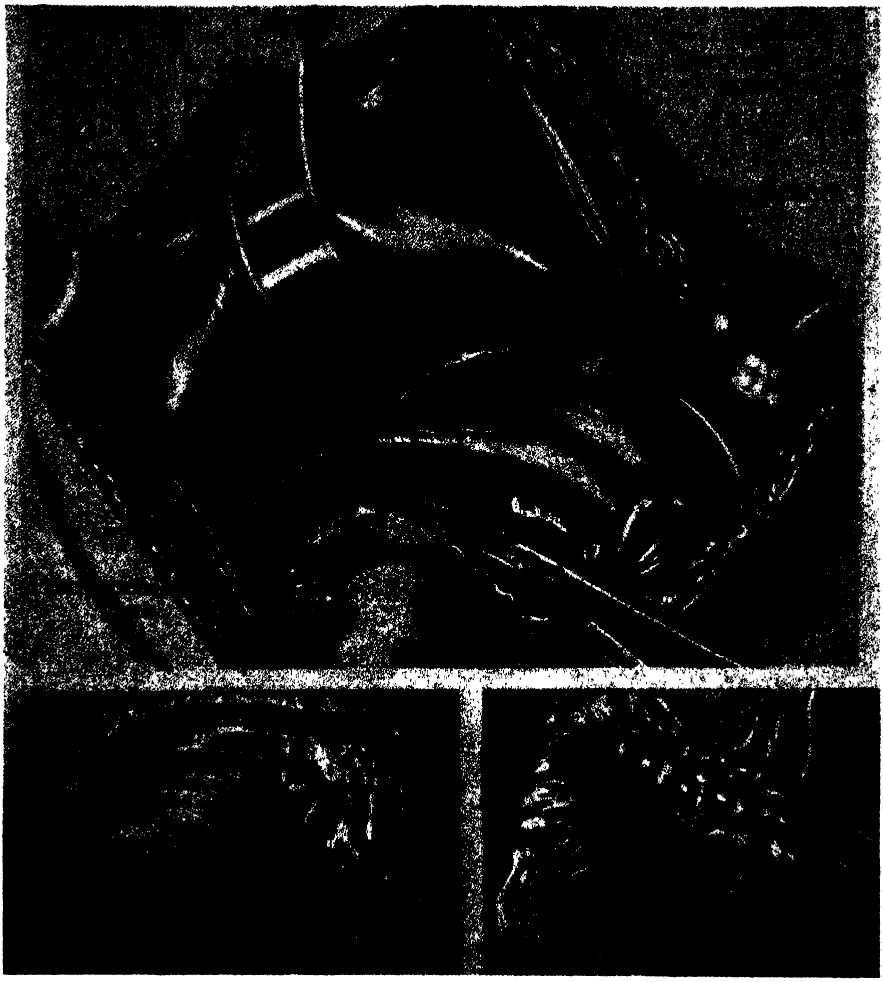

Fig. 536.—The abdominal operation for diaphragmatic hernia.

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or, in the absence of a sac to the pleura, the pericardium or the lung. The surgeon must never be tempted to use strong traction from the abdomen, as serious damage may be done to the thoracic viscera. If gentle traction and mobilization with the finger do not succeed in releasing the contents it will be necessary to open the chest freely by an incision along the eighth rib or adjoining interspace so that the adhesions may be dealt with under the guidance of the eye. During the process of reduction from the abdomen the sac may be inverted into the peritoneal cavity and may be cut away. It is not essential to make any great effort to remove the sac, as it seems to look after itself.

Once the contents have been withdrawn, an attempt must be made to close the aperture in the diaphragm and this can usually be accomplished successfully. The freshened margins may be drawn together without difficulty and may sometimes prove so lax that they can be overlapped. Interrupted sutures of stout chromicized catgut should be used for the closure, which can often be reinforced by applying the mobilized left lobe of the liver to the sutured area. The two ends of the last suture of closure are left long and are passed on a needle through the left lobe of the liver about an inch apart and are then tied in order to apply it firmly to the under surface of the diaphragm over the suture line. If the margins of the aperture in the diaphragm cannot be drawn together because of tension, the gap may be entirely covered by applying the liver to its under surface, or the aperture may first have to be laced over with fascial strands cut from the thigh. Whenever there is tension or difficulty in getting the margins into apposition, the catgut sutures ought to be supplemented by fascial strips. Sometimes it is much less difficult to close the hernial orifice from the thoracic surface of the diaphragm than from below.

In strangulation the patients are frequently so ill that the least possible interference must suffice, and if the condition can be relieved by opening the abdomen and withdrawing the intestine from the hernia into the peritoneal cavity, the radical cure may have to be left until another time. There is, however, great risk of recurrence of this complication and the radical operation should not be too long delayed.

Sometimes the stomach has been so long in the chest cavity and is so much distended that there does not seem room for it in the abdomen. In these circumstances Sir Thomas Dunhill has found it advantageous to perform temporary gastrostomy. This has the further advantage that it anchors the stomach to the parietes, counteracting the tendency for it to be drawn up into its old position in the chest.

In hiatal hernia there is usually not much difficulty in reducing the stomach which is the invariable content. The hiatus may be sufficiently narrowed by drawing the anterior part of the opening together but care must be taken not to displace or unduly compress the œsophagus.

There is a considerable risk of collapse of the lung after these operations, and Stuart Harrington, of the Mayo Clinic, strongly advises that the patients should be nursed in an oxygen tent.

" Finally it must be realized that surgical intervention is always serious and that there are many possibilities of disaster. Even in the presence of symptoms a conservative policy deserves serious consideration. The milder troubles may often be relieved by the treatment of associated lesions and perhaps by the occasional passage of the stomach tube. Phrenicotomy, by relieving diaphragmatic spasm, has given great relief and is a useful preliminary if surgical intervention is required." (Grey Turner, The British Encyclopædia of Medical Practice.)

Mortality.—The mortality of operative treatment is not less than 10 per cent. The final results are reasonably satisfactory but should be judged by the relief which the patient obtains rather than by the subsequent X-ray appearances.

CHAPTER XXIV

OPERATIONS FOR CANCER OF THE RECTUM

By G. GREY TURNER

Surgical anatomy of the rectum and anal canal.—The rectum extends from the middle of the third piece of the sacrum to a point one and a quarter inches in front of and a little below the level of the tip of the coccyx, where it is continuous with the anal canal.

It is about 5 or 6 in. in length and lies at first on the anterior surface of the sacrum and coccyx and then on the ano-coccygeal raphê of the levatores ani muscles. The latter sweep round the sides of the lower one-third of the bowel to reach the raphê where they gain insertion ; in doing so they separate the rectum from the ischio-rectal fat.

In its upper one-third the rectum is covered in front and at the sides by peritoneum, in the middle third in front only, and in the lower third is devoid of peritoneum and is embedded in a sheath of pelvic cellular tissue lying on the deep surface of the levatores ani (fascia propria). (Fig. 537.) Between the rectum and prostate and the base of the bladder in the male and the vagina in the female there is a definite plane of cleavage in this cellular tissue and when this is opened up the bowel can readily be separated. Thickenings in this cellular tissue run backwards to the sacrum (suspensory ligaments) and laterally along the middle hæmorrhoidal vessels.

The peritoneum passes from the anterior surface of the rectum on to the upper part of the posterior wall of the vagina in the female, and on to the bladder in the male. The reflexion is further from the surface of the perineum in the male than in the female and is about three to four inches from the anal verge. As the peritoneum reaches its lower limit it is only loosely connected to the rectum by fatty areolar tissue. When exposed from below in the operation of rectal excision, the peritoneum can be separated to some extent from the rectum by gently pushing it aside, using the method of gauze stripping.

The lower third of the rectum is dilated, this portion being called the ampulla. Just beyond, at the perineal flexure, the rectum joins the anal canal at almost a right angle.

The anal canal, about one and a half inches long, is related posteriorly to the ano-coccygeal raphê, laterally to the levatores ani, and anteriorly to the apex of the prostate, the base of the triangular ligament and the bulb of the urethra covered by Colles' fascia. In the female the vagina is related to it anteriorly. The canal is surrounded by the internal sphincter deep to the levator ani, and by the external sphincter superficial to that muscle.

The mucous membrane of the rectum is covered by columnar epithelium containing mucous glands, and in the lower part is very

Fig. 537.—Dissection showing posterior surface of rectum, with the fascia propria or sheath, the superior hæmorrhoidal vessels, perirectal fat, and some of the lymph nodes.

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loosely attached to the underlying muscle. The lining of the anal canal presents three zones :—the uppermost shows vertical folds, the columns of Morgagni, which are joined to one another below by the semilunar anal valves ; this part is covered by cubical epithelium. The second zone is covered by stratified squamous epithelium, and the third zone, the anus, by true skin.

The blood supply is derived from the superior hæmorrhoidal artery which is the continuation of the inferior mesenteric, the middle hæmorrhoidals from the internal iliac above the levator ani, and the inferior hæmorrhoidals from the internal pudic below that muscle. The terminal branches of the superior hæmorrhoidal artery run vertically in the columns of Morgagni and anastomose freely with the other two vessels in the lower part of the anal canal.

The veins form two plexuses. The internal plexus in the submucosa drains mainly into the inferior mesenteric *via* the superior hæmorrhoidal vein. These, being radicles of the portal system, have no valves. The external plexus outside the muscle coat communicates with the internal plexus and goes to form a superior hæmorrhoidal vein of considerable size and importance. It receives radicles from the sigmoid and descending colon, and eventually joins the splenic vein close to its junction with the superior mesenteric to form the portal vein. Thus, there is a direct connexion with the rectum, and septic conditions there can easily produce portal pyæmia. Carcinoma may also directly invade the veins and so reach the liver.

The **nerves** are derived from the sympathetic and the parasympathetic, the latter distributed through the second, third and fourth sacral nerves. The major part of the sympathetic supply comes from the inferior mesenteric plexus, the fibres running with the superior hæmorrhoidal artery and its branches. Some part of this supply travels *via* the presacral or hypogastric nerve. The final distribution of these nerves in the rectal wall and to the muscles concerned is similar to the arrangement in other parts of the alimentary canal. It is the function of this nerve supply to supervise the extremely delicate mechanism of co-ordination between the powerful sphincteric apparatus and the propelling force of the strong muscular wall of the rectum. The fact that the sympathetic nerve supply to the bladder and to the pelvic organs of women travels by similar sympathetic channels explains the upset of their functions in rectal disease. The mucosa of the anal canal is extremely sensitive while that of the rectum proper is comparatively insensitive.

The **lymphatics** begin as plexuses in the submucous and muscular layers of the lower bowel. As with lymphatics elsewhere in the bowel, these collect into vessels which pass through the muscular coats, and on the outside of the rectum run with the veins and converge towards the middle line posteriorly. Less important lymphatics accompany the middle hæmorrhoidal vessels, and finally drain into lymph nodes along the internal iliacs. The study of pathological conditions, rather than anatomical injections, prove that by far the greater part of the lymph drainage runs through the lymphatic channels which pass towards the mid-line and travel upwards in company with the branches of the superior hæmorrhoidal vessels. The first lymph nodes into which they discharge their contents are the para-rectal or retro-rectal nodes which lie on the outer aspect of the rectum posteriorly and postero-laterally among the fat and cellular tissue which goes to form the fascia propria or sheath of the rectum. These nodes are well marked and constant but vary in number and size. Where the venous branches collect into a single trunk, about the level of the upper part of the ampulla, the nodes leave the bowel and lie in the meso-rectum as the superior hæmorrhoidal chain of lymph nodes. From the latter, efferents pass to the inferior mesenteric and aortic nodes. The lymphatics of the lower part of the anal canal and those from the anal margin drain into the superficial inguinal nodes. They probably decussate in their passage so that the nodes in both groins may be involved in what appears to be a unilateral lesion.

Spread of cancer of the rectum.—This must be considered under three heads ; (*a*) by direct extension through continuity of tissue, (*b*) through the venous system, and (*c*) by the lymphatic system. At the outset it should be realized that, although most carcinomas of the rectum grow slowly, and their life-history extends over two or more years, nevertheless in about 20 per cent. of cases the disease spreads rapidly and disseminates early, so that the life-history is then a matter of only a few months.

The growths can be classified according to their gross pathological features into three groups (Dukes). A. Those which proliferate on the surface and form the papillomatous type. B. Those in which ulceration and penetration of the bowel wall is the main feature but without glandular metastasis. C. Those with deep ulceration and glandular involvement. Dukes stated that involvement of glands does not usually occur until the perirectal tissues are invaded. This all goes to show that at its inception, and in many cases for long afterwards, carcinoma of the rectum remains a local disease.

As far as *extension in the rectum* is concerned, growth is slow, and tends to encircle the bowel, the time taken being about eighteen months for three-fourths of the circumference. The growth becomes adherent to the muscular coat before half the circumference has been encompassed. When the whole thickness of the wall has been infiltrated the growth invades the perirectal fatty tissue, but does not reach the fascia propria till more than a year has elapsed. Until the fascia propria has been penetrated, no fixation to surrounding structures takes place. (Ernest Miles, 1939.) The growth may then invade the base of the bladder, the vagina and uterus, the presacral tissues and the peritoneum. The extent to which permeation occurs in the rectal wall above the growth has been much discussed, but recent investigations in large numbers of cases have shown it to be infrequent.

Extension by the venous system is not common, but occasionally metastasis in the liver may be found in cases which otherwise seem favourable for radical cure.

The frequency of this method of spread is difficult to estimate. Histological evidence of direct involvement of veins is found in comparatively few cases, but malignant emboli may be carried to the liver in the blood stream without leaving any trace.

The mere fact that lymph nodes are enlarged and palpable is not necessarily evidence of invasion by growth, and many such nodes turn out to be inflammatory. Lymph nodes are more frequently invaded in younger subjects, and more often in women than in men. Careful studies have shown that they are not likely to be infiltrated by growth unless the peri-rectal tissues are invaded. For the most part, lymphatic invasion follows a regular course and spreads from node to node, though in the very malignant cases this sequence may fail and a node in a superior group may become invaded before those of intervening groups. Spread to lymph nodes below the growth, or nodes on the levatores ani, is a late phenomenon, only found in inoperable cases. Permeation of lymph vessels is rare, and only seen in very malignant cases.

Operability.—The first point to consider is distant dissemination. Unequivocal demonstration of secondary deposits in the liver means that no radical operation is justifiable. It is a great reflection on our diagnostic acumen that in most cases the condition of the liver can only be determined by palpation during laparotomy. Direct extension of the growth to the peritoneum may give rise to ascites, and the presence of fluid in the abdomen is strong presumptive evidence that such an extension has occurred. It is not possible by ordinary examination to determine the state of the lymph nodes in the vicinity of the growth. Because dissemination may be present without giving rise to symptoms or signs, it has become the practice during recent years to make an exploratory laparotomy the first stage of the surgical management of any but the earliest and most favourable types of growth. The local condition bearing on operability is extension beyond the bowel wall and especially to the structures at the base of the bladder. For this reason growths situated on the anterior wall of the rectum are of worse prognosis than those situated posteriorly. Involvement of the vaginal wall or even of the uterus itself, though serious, is not necessarily a bar to successful intervention. The criteria of local extension may be gross, as when the growth ulcerates into the vagina or the bladder, but in the great majority of cases it takes the form of fixation. Absolute fixation or stony hard infiltration, as if the parts were imbedded in plaster of Paris, means such a degree of extension that radical operation is out of the question. In some few cases a certain amount of fixation is due to inflammatory disturbance and will disappear, or very much improve, after colostomy. A growth that can be moved on the bowel wall with the examining finger or that comes down on to the finger when the patient strains, has probably not penetrated the bowel wall. Though high situation of the growth means that its operative removal will be a more serious undertaking and will usually involve a combined operation, it does not mean that it need be inoperable. It is most important that the surgeon should not be easily deterred from undertaking operative treatment, for it is far more serious to declare a condition inoperable, when perhaps with the exercise of more courage the growth might have been removed, than to undertake an operation in which satisfactory removal turns out to be impossible. In borderland cases the patient should be given the chance of exploratory laparotomy which may prove that the fear of dissemination is groundless. As a result of preliminary colostomy there may be such a degree of improvement in the local condition that operation becomes not only feasible but favourable. The general condition, as shown by the state of the respiratory, cardio-vascular and renal systems, though it may modify the scope of the operation and may add to its gravity, can seldom be a determining factor against intervention except in borderland cases. The sex, the age and the anatomical build of the patient may have a bearing on the method of removal to be employed and may add to or lighten the technical difficulties, but they cannot be factors determining against operation when conditions are otherwise favourable.

The mortality from the disease remains high, and for this many reasons can be advanced. Perhaps the most important is that when the patient seeks advice the chance of a successful removal has already in many cases gone by. The early symptoms are often indefinite, and many patients, especially those with little or no pain, will not consult their medical attendant until the late symptoms of diarrhœa, tenesmus, or even partial obstruction, compel them to do so. By that time the growth may have become fixed, or distant metastasis may have occurred. By the adoption of bolder methods, by the two-stage method of operating, and especially by more careful and thorough preparation, many cases which only a few years ago were looked upon as inoperable can now be dealt with. Even to-day a radical cure cannot be attempted in about a quarter of the cases when they present themselves for examination. This is not only the result of delay in diagnosis but is due to the fact that a certain proportion of the cases disseminate early.

The different operations which may be employed.—To avoid misunderstanding, the following are the terms used for the operations which will be described.

1. Local excision of a small growth.
2. Local resection with preservation of the sphincters, carried out from the perineum and known as " lower conservative resection."
3. The extended perineal excision with preliminary inguinal colostomy.*

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* The word " extended " is employed to distinguish this operation from the old " perineal excision," which was admittedly a much too limited removal

4. The perineo-abdominal excision, that is, an excision begun and largely carried out from below, but completed through the abdomen (Grey Turner, W. B. Gabriel).
5. The abdomino-perineal excision (Ernest Miles).
6. Abdominal removal with (*a*) permanent colostomy, (*b*) restoration of continuity: the "upper conservative resection."
7. Abdomino-anal conservative method—the pull-through operation of German surgeons.

The operations will be described in the order in which they are most frequently employed.

Preliminary considerations.—The interests of patients suffering from malignant disease of the rectum will be best served if the surgeon considers which operation is particularly suited to the case rather than if he endeavours to make some one operation fit every variety of pathological and other circumstance. The age, the sex, the build of the patient and the general state of health, as well as the site and the type of the growth, may all have an influence on the selection. The first consideration is to make sure, as far as possible, that there is no distant dissemination. If this can be excluded, then the local conditions of the growth must be carefully studied. When the latter involves only a part of the circumference of the bowel and can be readily moved from side to side with the examining finger, or when up-and-down movement during straining can be demonstrated by the finger, it is probable that it can at least be successfully excised, though there is no means by which the condition of the lymphatic glands can be certainly determined before operating. On the other hand, if the growth surrounds the bowel and is fixed, as demonstrated by the finger, and especially if the fixation is on the anterior aspect of the rectum, it is improbable that it can be successfully removed. As it is often impossible to be quite sure that the liver is free from growth and that there are no secondary deposits in the glands, many surgeons make it a universal practice to open the abdomen in the middle line so that this point can be settled by direct exploration. This examination can also be made through the oblique incision in the left iliac fossa, which may subsequently be used for colostomy, but for the purpose of exploration it must be 3 or 4 times as large as would suffice for colostomy and there is then the probability that a ventral hernia will develop, in which the colostomy would be situated. For these reasons it is better to make a midline incision for the exploration with an independent opening for the colostomy.

Choice of operation.—If the growth is of the papillomatous type, is within such easy reach of the anus that the examining finger can explore all round it, is no larger than a two-shilling piece, can be freely moved with the mucous membrane and there is no suspicion of dissemination, it is a case in which the conservative operation should be considered. Any growth which is suitable for interference and which is within easy reach of the finger can be operated upon from below by the extended perineal method. Some surgeons believe that all such cases have a better chance of ultimate cure if the operation is a combined one. If, on the other hand, though the growth can be felt, it is just at the tip of the finger and the latter cannot reach beyond it, then this indicates a growth at the pelvirectal junction and means that a combined operation must be carried out. There are some few cases belonging properly to the highest part of the rectum in which the operation can be conducted entirely from the abdomen. Big, stout men and patients who are poor risks on account of their general health stand a better chance of recovery when the operation is carried out from below.

Colostomy v. sacral anus.—In certain cases which can be operated upon entirely from the perineum, it is possible to do a successful operation and to leave a sacral anus, but experience has shown that if a patient must tolerate an incontinent anus, it is much better to have it situated on the front of the body where it can be looked after by the patient under the guidance of the eye. That being so, it is recommended that, even if the perineal route is to be employed, the abdomen should first be opened in the middle line for exploration and this should be combined with colostomy. Whether or not this should be done as a preliminary operation, or as a first step of the perineal operation, depends on the presence or otherwise of obstructive symptoms, and also on the general condition. For the most part it is better to divide the operation into stages and to make the exploration and colostomy first, and in a fortnight or three weeks to carry out the excision from the perineum. But the time that must elapse between the two operations depends entirely on the progress which the patient makes. It is most important that he should have the full advantage of the preliminary colostomy and should also have ample time to recover from the effects of this stage of the operation. If the abdomino-perineal operation is to be carried out, it also may be done in two stages. Many who advocate this operation, including its originator, do it in one stage, but they take care to spend as long as may be necessary, even up to a week or 10 days, in the preparation of the patient.

Preparation for operation.—Nothing has done more to improve the results of abdominal operations than proper preparation, and this has been especially evident in bowel growths. The patient should be admitted to hospital or nursing home several days before operation for rest and investigation and to become acclimatized to the surroundings. During this period there must be a general overhaul of all the systems; in elderly patients the renal function especially requires careful scrutiny. Bronchial irritation and infection should be treated, and smoking reduced to a minimum. Anæmia requires attention and if, necessary, blood transfusion should be employed. In any event the blood group must be determined and the pulse-rate and blood-pressure recorded. The diet should be generous but of a low residue and high nutritive value. The bowel should be emptied by mild purgatives assisted by liquid paraffin and moderate-sized wash-outs and, though the cleansing process should not be too drastic, it must be thorough. Nervous patients may require some sedative but morphia should not be used in the pre-operative period. No purgative should be given during the twenty-four hours immediately preceding operation, but the rectum should be emptied by a glycerine enema on the evening before.

Anæsthesia.—With the two-fold object of diminishing shock and reducing the amount of inhalation anæsthetic required, it was my practice to employ a combination of spinal or local anæsthesia with inhalation anæsthesia. Accumulating experience, however, suggests, rather than proves, that both the spinal and the local anæsthetic lower the resistance of the tissues and that wound-healing and repair are better if they are avoided. Pre-medication with scopolamine and omnopon, followed by gas-oxygen-ether anæsthesia skilfully administered, usually provides ideal conditions for both surgeon and patient and is followed by very good results.

Care of patient during operation.—The pulse and blood-pressure should be carefully watched from the outset, and intravenous glucose saline or blood administered at the first sign of deterioration. Proper co-operation between anæsthetist and surgeon should result in the prevention of serious shock. Any necessary change in the position of the patient should be very carefully carried out, and this especially applies to the concluding stages of the operation.

THE EXTENDED PERINEAL EXCISION AFTER PRELIMINARY EXPLORATION AND COLOSTOMY

First stage.—Exploration of the abdomen is made through a median sub-umbilical incision with left inguinal or transverse colostomy. As a rule the condition of the patient rapidly improves. The lower bowel is cleansed by irrigation with normal saline. Ordinary nourishing diet is allowed, and at the end of a fortnight the patient may get out of bed. If improvement is slow or there is marked anæmia, blood transfusion may be helpful.

Second stage.—About three weeks later the second operation is carried out. The patient is placed in the left semi-prone position, with the thighs well flexed and the buttocks right up to the edge of the table. The right arm should be supported on a rest. The anus is closed by a subcutaneous purse-string of stout silk. The incision starts from the side of the base of the sacrum and is carried forward in the midline, surrounding but well clear of the anus, to meet in the midline ½ in. in front of the anus. (Fig. 538.) It is deepened through the subcutaneous tissue and well retracted. At the lower end the muscular fibres of the external sphincter come into view, while at the upper end the lower borders of both gluteus maximus muscles should be exposed. By deepening the incision between these two points, the inferior surfaces of the levatores and gluteal muscles are seen and should be cleared close up to their origins. The separation of the rectum from the urethra and prostate is the next step. The ends of the suture used to close the anus should be left long and knotted together to form a loop, which makes a convenient retractor for drawing the anus away from these parts. The actual dissection is best made with blunt-pointed scissors and these must be used with the blades kept parallel with the prostate and bladder base. Some surgeons make a practice of tying a gum-elastic catheter into the urethra to act as a guide, but after a little practice this structure can readily be identified by its appearance and by touch. When the anterior fibres of the external sphincter are divided transversely at the central point of the perineum the bulb of the urethra comes into view and as the rectum is drawn backwards this structure can be gently thrust forward by gauze stripping. Drawing on the rectum makes the anterior fibres of the levator ani prominent and they should be snipped through lateral to the middle line. This step allows the anal region to be further drawn away and the urethra better defined so that, with a snip or two of the scissors, the plane between the prostate and rectum is opened up. The division of the levator ani is continued still further back on either side ; it should be cut about half an inch from its attachment to the white line. If it is divided nearer that structure there may be bleeding which is a little difficult to check. Once the proper plane of cellular

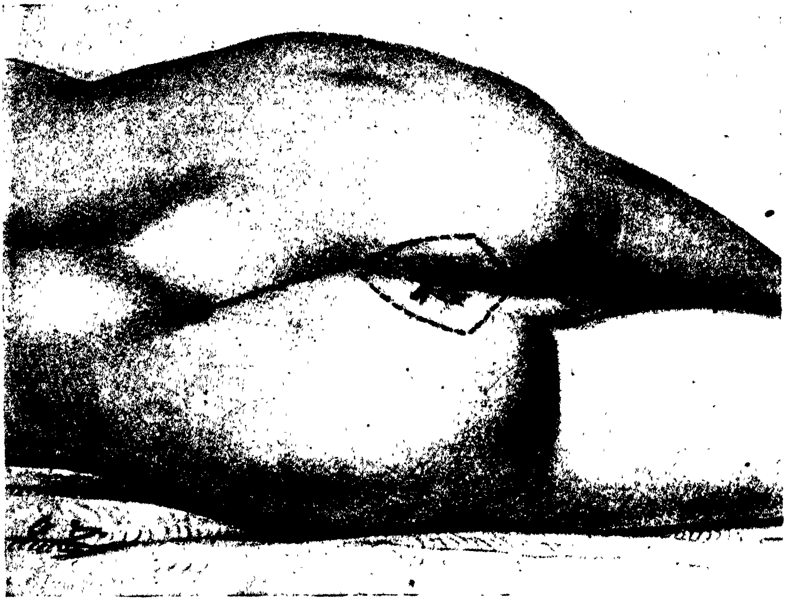

Fig. 538.—Complete removal of rectum from below : the anus is closed by a purse-string suture and the extent of the incision demarcated.

tissue is found between the rectum and prostate or vagina, those structures can be separated with great ease by gauze stripping; it is only when there is inflammatory induration or actual invasion by growth that the scissors are necessary. The separation is now continued anteriorly until the peritoneal reflexion is reached and a large moist swab is lightly packed into the area.

Attention is now given to the upper posterior attachments of the rectum, and the region of the coccyx is exposed. In fat or bulky subjects it may be an advantage to carry out this step at an earlier stage. The coccyx is defined, separated from its attachments and removed. The bone is separated from the sacrum by disarticulation and this is best done with the knife rather than the bone forceps, although in elderly patients the latter may have to be employed. During this step the termination of the middle sacral artery may be divided or torn; it can seldom be caught, but the bleeding is arrested by packing a gauze swab firmly up against it. The division of the levatores ani is now carried right back to the side of the coccyx, and some fibres of the coccygeus are also divided. The rectum is now separated from the front of the sacrum, and this can usually be done by making a transverse cut with the scissors through the strong fascia just opposite the end of the bone. The finger introduced ust in front of the sacrum can then easily thrust the structures orwards, except when there is induration, in which case a pair of

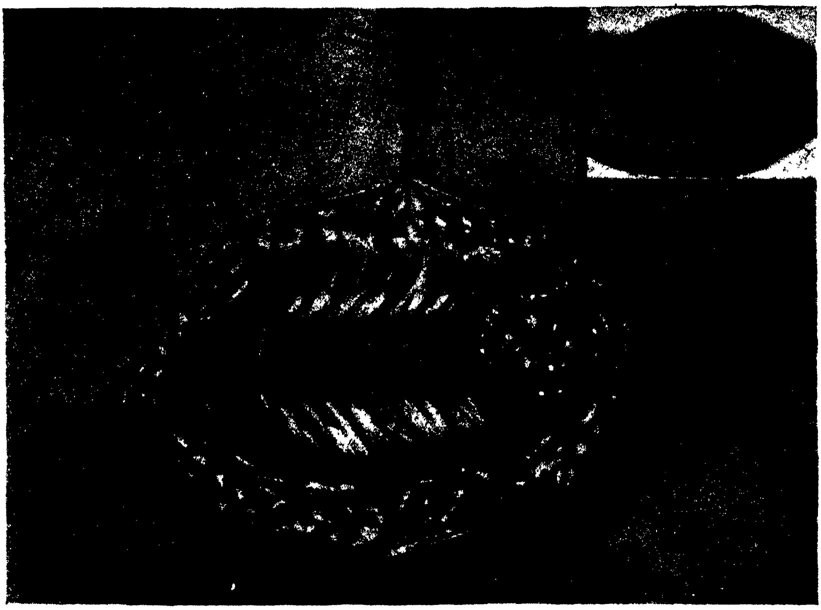

Fig. 539A.—Complete removal of rectum from below.

The anus has been closed and isolated with surrounding skin. The median raphé and the levators ani are exposed and the coccyx has been disarticulated. Inset: incision.

blunt-pointed scissors or a gauze mop on a handle may be introduced and used gently as a lever. As soon as the space is freely opened, the rectum is felt to be mobilized and can be drawn down considerably. The lateral ligaments are caught and divided and are better ligatured at this stage. The rectum should now be wrapped in gauze and freely turned backwards, exposing the anterior aspect. After the removal of the gauze which was temporarily introduced, the peritoneum of the recto-vesical or pouch of Douglas can be caught in artery forceps and opened with scissors. The opening is then enlarged round the sides and half an inch away from the bowel. This may suffice to allow the bowel to be brought sufficiently down to expose it for division well

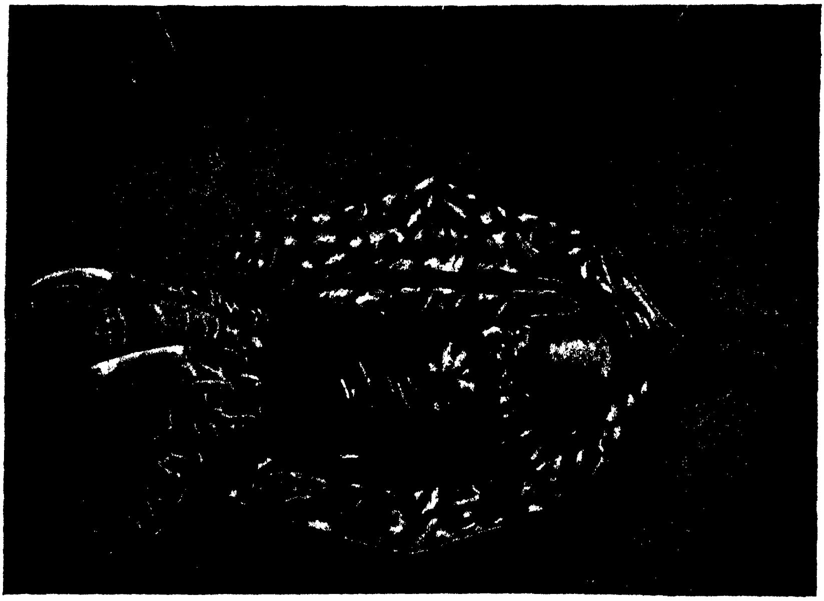

Fig. 539B.—Complete removal of rectum from below.

The levatores ani have been divided and the separation of the anterior part of the rectum begun.

above the growth but if it does not do so the postero-lateral peritoneal reflexion may be divided upwards by the side of the bowel for two or three inches. The peritoneal cavity is temporarily packed with a large gauze secured with a pair of artery forceps.

Attention must now be turned to the meso-rectum. If easily accessible, this may be caught in artery forceps, divided and ligatured. Quite often it is not easy to expose, in which case a ligature may be passed through it with a handled needle or a needle in a holder. The main trunk or some large branch of the superior hæmorrhoidal may lie so close to the bowel as to be almost buried in its wall, and care must be taken to see that such a vessel is not missed and allowed to retract. In most cases the vessels can be caught and ligatured off in this way, though at times only with considerable difficulty.

On rare occasions it may be necessary to leave a pair of artery forceps on a vessel which has eluded ligature. This is no reproach if it is to be the means of preventing a death from hæmorrhage.

The bowel must now be divided, and this must be done at the highest convenient spot and not less than three or four inches above the upper margin of the growth. The ideal plan is to cut the bowel with the cautery between clamps but it may be very difficult to apply an upper clamp. In these circumstances the bowel can be crushed by forceps and a ligature applied to the crushed area. The ligature must be very tightly tied as there is a risk of some part of the bowel retracting into the lumen. If there is any question about the security of the closure it is necessary to pass a strong suture across the end of the bowel. If the division is not made with the cautery the cut surface should be thoroughly swabbed with pure carbolic. Whenever possible, the end should be buried with a purse-string or other suture. The stump closed in this way should be placed just within the peritoneal cavity, which is closed with a continuous or a series of interrupted sutures. If the cut end of the bowel cannot be buried and returned to the peritoneum, the edge of the latter should be sutured to the bowel at one or two points and the remainder closed. A finger-size rubber tube should be threaded on to one end of the ligature used to tie the bowel and run along until it lies in contact with the end of the bowel. (Fig. 539.)

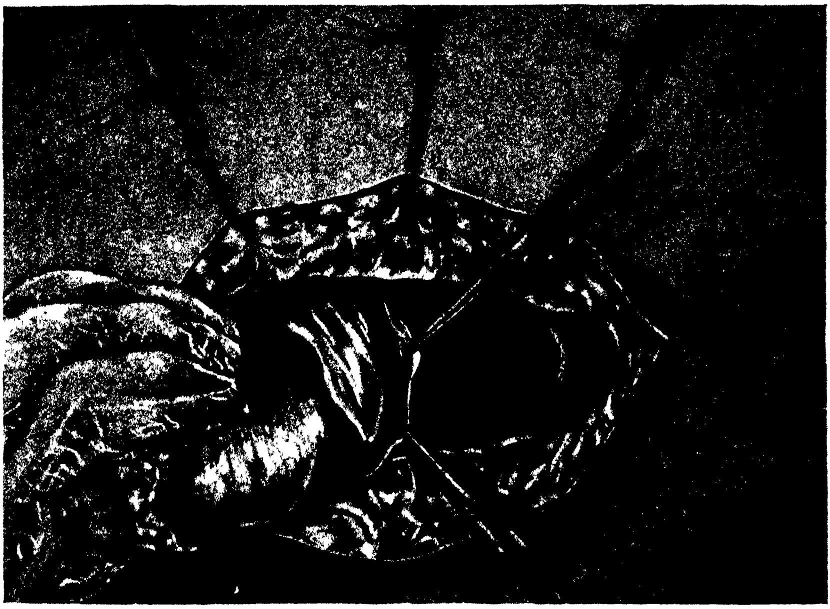

Fig. 539C.—Complete removal of rectum from below.

The rectum is largely free ; the prostate and seminal vesicles, with the base of the bladder, are exposed, and the peritoneum of the recto-vesical pouch is freely opened.

Attention is next paid to the toilet of the large wound and any vessels still bleeding must be caught and ligatured. Oozing areas, where there are no individual vessels to tie, should be under-run or overstitched with catgut. If the operation has been sufficiently radical it will be impossible to close the depths of the wound, though something may be done to diminish its size at the anterior part by deep sutures. If there is oozing that cannot be controlled by suture, or if the wound has been soiled, perhaps by accidental injury to the bowel during the course of the operation, it is better to pack it lightly with gauze. Otherwise, a softened rubber tube may suffice to provide for the escape of imprisoned air and exudate. Except for the passage of the tube or gauze, the whole wound should be carefully closed by suture, great care being taken to get the subcutaneous tissues in contact. The sutures at the anterior end should be of chromicized catgut so that there are no sharp ends to prick the patient when the thighs are brought together. For the remainder of the wound, silkworm-gut makes the best suture material. The dressing should be anchored in position with sutures or strapping, and care should be taken to protect the area against accidental infection. At the conclusion of the operation the patient should be slowly and very gently turned on to the back, for sudden reversal of position may bring on collapse. In a very easy case the operation may be completed in

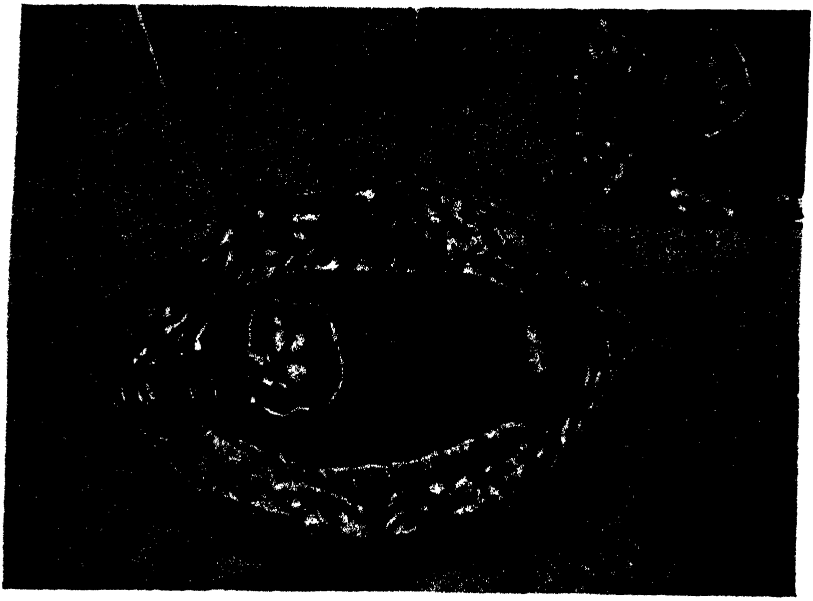

Fig. 539D.—Complete removal of rectum from below.

The rectum has been removed and the cut end closed by purse-string suture ; the peritoneum is being closed by interrupted sutures. In the inset the lower end of the bowel is being fixed to the peritoneum with the sutures of closure and a tube is placed down to the sutured end.

three-quarters of an hour but one and a quarter to one and a half hours is a more usual duration.

Difficulties during operation.—If for any reason the bowel cannot be sufficiently mobilized to allow it to be drawn down and divided a safe distance above the growth, the surgeon must make up his mind to turn the patient over and to open the abdomen so that the operation may be completed from above as in the perineo-abdominal method. On the other hand if the difficulty is due to unexpected extension of the growth beyond the bowel wall, then the part of the rectum so far isolated should be removed and the operation terminated as an incomplete removal.

Injury to the urinary apparatus.—The urethra may be cut across or a portion may be excised from its wall. The accident ought to be recognized at the time, in which case the urethra should be repaired by interrupted sutures of catgut passed with a fine curved needle. If the injury is not extensive, a rubber catheter should be passed *per penem* and tied in ; with an extensive injury it is better to divert the urine through a suprapubic drain inserted with the Morson trochar. Growths situated anteriorly may directly involve the prostate or seminal vesicles. If it is possible to get beyond the edge of the growth, by taking a slice from the prostate or removing one or both seminal vesicles, this may be done without hesitation. The base of the bladder has been opened in mistake for the peritoneum or in cases where the viscus is adherent to the growth. Any such wound must be carefully repaired by two layers of suture and either a catheter tied in *per urethram* or a suprapubic drain inserted. In either case the bladder must be irrigated daily during convalescence. Following this injury, or a urethral wound, a urinary fistula may result but may heal satisfactorily, even after several weeks. Leakage of urine from the wound after some days is more inconvenient than dangerous.

In the female the posterior wall of the vagina may be inadvertently opened, but any hole or tear can be securely closed by suture. If the vaginal wall is adherent, an ellipse or a strip extending up from the vulva may be deliberately excised with the growth. Careful repair by suture should always be carried out at the conclusion of the operation. An unsutured communication between the vagina and the wound is apt to persist as a fistula, which may be very disagreeable in women who are still menstruating. There are some cases in which the vagina and uterus are both involved but in which these organs can be successfully removed with the rectum by the posterior route.

Comments on this operation.—It is most important that the operation should be done with perfect illumination, and with a field unobscured by hæmorrhage, so that the surgeon may clearly see the anatomy of the parts with which he has to deal. In these circumstances the urethra and prostate; etc., can be safely preserved from harm without a catheter as a guide, though the beginner should not neglect this aid. It is well to avoid cutting through any part of the sacrum, because if there is even a mild infection of the posterior part of the wound, the exposed bone is apt to become involved, and healing may be very slow, or a sinus may form and persist. The separation of the tissue about the rectum must be carried out very thoroughly, and the surgeon should avoid dividing the levatores ani too near the bowel. If, after dividing these muscles and the recto-sacral ligaments, the rectum cannot be drawn down it probably means that the growth is too much fixed for satisfactory removal. The surgeon must take the greatest care to avoid blood loss and as far as possible vessels should be caught before being divided, and should certainly not be allowed to go on bleeding after division. When it is not possible to turn in the end of the bowel by suture, and it is necessary to bring a drainage-tube from the bowel end through the wound, there may be no leakage and the wound may heal up as well as if the bowel end had been neatly tucked in. In other cases a small mucous fistula persists. After removal of the rectum the cavity left may be very large and even if there is not much oozing it may be wise to leave in a large gauze as a temporary support for the pelvic floor. For this purpose a sheet of gutta percha tissue may be laid in the pelvic cavity and gauze may be packed into it like a Mickulicz pack. This plan greatly facilitates the removal of the gauze, but it is not effective for the arrest of oozing. After removal of the gauze, a tube may be introduced to prevent the skin-edges falling together and damming up discharge. Should the patient be seriously shocked at the conclusion of the operation, or should there be a great deal of oozing, then to save time the wound may be packed and left entirely without suture. It is quite surprising how quickly large wounds of this sort will heal by granulation.

After-progress and subsequent treatment.—Though the patient may leave the theatre in good condition, a certain degree of shock may develop later, and must be treated appropriately. The patient should never be allowed to lie for hours in a state of severe shock ; if response to ordinary measures is delayed, blood transfusion should be promptly carried out. After this operation, though the patients pass urine, they often do not empty the bladder completely, and for this reason a catheter should be passed once in 24 hours for the first week. Of course if there is complete retention it will be necessary to catheterize at least every 12 hours, and oftener if there is discomfort. This plan is considered to be better than leaving a catheter tied in, though at St. Mark's Hospital the latter is the usual practice. But whenever catheterization is necessary, urotropin should be given thrice daily in 10 gr. doses and the bladder should be irrigated with oxycyanide of mercury, 1 in 8,000, every 24 hours. The bowels are usually moved by the colostomy on the third or fourth day. Liquid paraffin may be commenced by the mouth on the third day and, if necessary, a laxative may be administered with it. For the after-care of the colostomy, see p. 896, vol. I.

The perineal wound may heal in its entirety by first intention, but there is often mild infection, with some discharge. During the process of healing, it is most important to see that drainage is good. This must be assisted by keeping the skin margins apart and by elevating the head of the bed or even allowing the patient out of bed at the end of three weeks. At this stage he cannot sit with comfort, but standing up greatly assists drainage. These wounds heal remarkably well by granulation. The time which must be spent in hospital is very variable. Generally speaking, the 3 weeks mentioned is the exceptional minimum and 5 to 6 weeks is much more like the average time.

PERINEO-ABDOMINAL EXCISION

This method, first described by Grey Turner at the Annual Meeting of the British Medical Association held at Cambridge in 1920,* was initiated in cases in which the surgeon set out to remove the rectum by the perineal operation, but found during the course of operation that the growth extended to a higher level than had been expected or that there were invaded nodes higher than could be safely reached from below. In these circumstances, the operation, having been carried out as far as possible from below, is completed by opening the abdomen and then performing what is practically the earlier stages of an abdomino-perineal operation. The bowel bearing the growth is either removed through the abdomen or is withdrawn through the posterior wound. Quite often this method enables the surgeon to get out of a difficulty with a fair prospect of success, when otherwise it might be necessary to abandon the operation altogether. Originally the perineo-abdominal method was intended to be a second-stage operation, the abdomen having previously been explored and colostomy carried out. W. B. Gabriel has devoted great attention to this operation and has evolved a most reasonable technique for its execution as a method of election in one stage. As in other cases of rectal carcinoma, he lays much stress on a preparatory period of from seven to ten days in hospital. The following is based on Mr. Gabriel's own description of the operation as set out in the second edition of " The Principles and Practice of Rectal Surgery," 1937 :—

Technique.—General gas-oxygen-ether anæsthesia with procaine infiltration of the recti muscles is considered better than spinal anæsthesia. The procedure is carried out in the following distinct steps :

1. For tumours in the upper third of the rectum, and for all tumours in the advanced or borderline category, an abdominal exploration is done through a right paramedian sub-umbilical incision. If no contra-indication to a radical removal is found, the wound is closed temporarily by four or five through-and-through silkworm gut sutures tied over gauze, inserted over and partly into the abdominal wound.
2. The patient is then turned into the left lateral position with the knees drawn well up. A small piece of dry gauze is tucked into

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* *Brit. Med. Journ.*, Nov. 13th, 1920, ii, 735.

the anal canal to minimize the risk of a mucoid leak during operative manipulations, and the anus is firmly closed by two purse-string sutures of stout silk. The perineal excision is then proceeded with on the lines described on p. 1115. After the rectum has been freed postero-laterally it is wrapped round with a 2-yard roll of gauze, and a sterile glove is tied over its end with two stout silk ligatures. After a little more blunt dissection anteriorly the peritoneal reflexion will be identified by the sliding of the opposed peritoneal surfaces on each other. With blunt-pointed scissors cutting towards the bowel, the peritoneum is opened, the incision being carried round the bottom of the recto-vesical pouch, and then upwards on each side of the rectosigmoid for as far as can be reached with long scissors. The rectum is further mobilized by cutting through the lateral ligaments, and when this stage has been completed the rectum will be rendered completely free, without any encroachment on the superior hæmorrhoidal vessels, and a large semilunar opening will have been made into the peritoneal cavity. The rectum is swabbed over with some dettol lotion and is then gently pushed up into the pelvis, and a large abdominal pack moistened with dettol lotion is placed in the perineal wound below it. The posterior third of the wound is closed by interrupted sutures of silkworm gut, and two or three similar sutures are inserted at the anterior extremity of the incision, leaving the central portion open. The wound is painted with iodine, and is covered with a dry pack and a folded sterile towel which is kept in position by two transverse strips of strapping.

3. The patient is now very carefully turned on to the back and placed in the Trendelenburg position, the abdominal wound is re-opened, and the small intestine packed aside. Deep in the pelvis the glove covering the rectum will be seen and, as a rule, even in a narrow male pelvis, the rectum can be readily delivered. The lateral peritoneal incisions are continued upwards on each side of the pelvic mesocolon, and with little difficulty the rectum and pelvic colon are stripped up till they can be delivered freely out of the abdominal wound. The inferior mesenteric pedicle is now clearly defined by traction on the bowel, and the optimum point for application of a double silk ligature is made out. Except in very stout subjects, the sigmoid arteries can be seen traversing the left iliac fossa, and the ligature is tied between the first and second or second and third sigmoid branches. The vascular pedicle is divided between the ligatures and, for additional security, a second ligature of catgut is tied round the upper end of the vessels. A left iliac muscle-splitting incision, 4 in. in length, is made and the rectum and pelvic colon are then passed through this incision so that the bowel is left lying on the abdominal towels. The pelvis is now empty and its floor is closed by drawing together the peritoneal edges, using a double No. 1 catgut stitch on a curved needle and eventually burying the ligature round the inferior mesenteric vessels. The paramedian incision is closed without drainage, and the left oblique incision is sutured in layers round the emerging colon.

The pelvic mesocolon is ligated about 1½ in. beyond the skin surface, gauze dressings are applied, and the bowel with the growth is cut away with the cautery between clamps, the division being an extra-abdominal manœuvre. The crushed edges of the emerging colon are separated, and a No. 15 rubber catheter passed into the open end and fixed by a stitch. The median abdominal incision is dressed with dry sterile gauze and is sealed off with a strip of elastoplast. Finally, the legs are held up and apart and the toilet of the perineal wound is completed. The wound is swabbed dry and hæmostasis verified ; a sterilized yellow rubber bag, or a large piece of thin rubber sheeting or gutta-percha tissue, is inserted into the cavity and packed with gauze. The remaining portion of the anterior third of the perineal wound is sutured and dressings are applied by lifting rather than rolling the patient. In certain cases the preliminary laparotomy has been dispensed with, the operation being carried out as a " blind " one-stage perineo-abdominal excision. The cases selected for this plan have been those in which a clearly mobile and certainly operable carcinoma has been present, with the entire length of the tumour within reach of the finger ; the " blind " method should not be attempted with a high lying or deeply ulcerated growth.

RADICAL ABDOMINO-PERINEAL OPERATION (MILES)

Of this operation Mr. W. E. Miles has kindly communicated the following description :—

" The object of this radical procedure is to embrace the tissues comprising the upward zone of spread in addition to those of the lateral and downward zones.

" By this means the whole of the pelvic colon (with the exception of the portion to be utilized for establishing the colonic stoma), together with the whole of the rectum encased in its sheath of fascia propria ; the whole of the pelvic mesocolon ; the peritoneum lining the floor as well as the walls of the true pelvis ; the whole of the levator ani and coccygeus muscles ; as much as possible of the ischio-rectal fat, and a wide area of peri-anal skin, are removed. The procedure should not be reserved for advanced cases only. It should be the choice for the earliest possible case in order that the microscopical spread in the lymphatic areas may be completely circumvented. Should it be reserved for advanced cases only, as sometimes advocated, the microscopical spread will have advanced beyond the confines of the operation field and recurrence will be inevitable. The operation is a surgical procedure of the first magnitude and should not be undertaken unless the patient's general condition is satisfactory. In order to ensure a successful result attention should be paid to (1) preparation before operation ; (2) choice of anæsthesia, and (3) details of after-treatment.

" **Preparation before operation.**—It is most important that a week or 10 days be devoted to preparatory treatment. A large number of patients suffering from cancer of the rectum also suffer from intestinal stasis, due in most instances to increasing obstruction to evacuation; in consequence, the contents of the colon are often exceedingly septic. Daily purgation and lavage not only empties the colon but reduces sepsis. In those cases in which the growth is situated at the recto-sigmoidal junction, the lumen of the bowel may be so narrowed that it is not possible to wash the colon out satisfactorily. In these circumstances, temporary cæcostomy should be performed and the radical operation postponed for a fortnight or three weeks. The plan which I have followed for several years past and which I have found to be very satisfactory is as follows:—

" 1. If on examination of the abdomen there are no signs of intestinal obstruction, the patient is given, on the morning of admission, 1 ounce of a mixture consisting of 2 drams of magnesium sulphate, 1 dram magnesium carbonate, and chloroform water to make 1 ounce, followed at hourly intervals by half an ounce of the same mixture until the bowels act freely. As a rule, five or six doses are required. If during this treatment there should develop signs of intestinal obstruction the mixture is discontinued; ½ grain of morphia is injected hypodermically, and cæcostomy is done at once.

" 2. On each succeeding morning until two days before the radical operation, 1 ounce of the mixture is given. A rectal wash-out of 1½ pints of plain water is administered every morning and evening and 5 grains of dimol are given twice daily as an intestinal antiseptic. The last dose of the mixture is given on the penultimate morning before the operation and the last wash-out on the morning before the operation, so that the intestinal canal should have complete rest for 24 hours. Several hours of sound sleep should be ensured by means of a suitable soporific.

" 3. During the whole of the pre-operative period and, in fact, until the morning of the operation, the patient is kept on a generous, nourishing diet.

" 4. The following investigations should be carried out before the operation: (1) Blood examination: (*a*) hæmoglobin, (*b*) blood-group, (*c*) blood-count, and (*d*) blood-urea. (2) Urine examination: (*a*) 24-hourly specimen, (*b*) catheter specimen, and (*c*) urea-concentration test.

" *Blood-pressure estimation.*—Systolic and diastolic pressures are taken while the patient is at rest in bed. I think it of very great importance that these pressures be accurately taken in order that cardiac energy can be determined by working out the Moots-McKesson 'pressure-ratio percentage.' This is one of the most valuable tests of operability and should never be omitted. If the pressure-ratio is below 25 per cent. the operation will be fatal and if above 75 per cent. the risk to life is increased. A cardiac energy index of 50 per cent. is the best possible.

" A thorough examination of general condition should be made, particularly of the heart and lungs.

" The patient should be kept in bed during the whole of the preparatory treatment.

"**Choice of anæsthetic.**—Ether or chloroform should never be employed, as they produce a marked fall in blood-pressure. So far as my experience goes, the best results are obtained from gas-and-oxygen anæsthesia supplemented by intrathecal injection of a 1 in 1,500 solution of percaine. The procedure that I adopt at the present time is as follows: the patient is given a subcutaneous injection of omnopon (gr. $\frac{1}{3}$) and scopolamine (gr. $\frac{1}{150}$) one hour before the time fixed for the operation to begin. At the expiration of the hour, and before the patient is taken from his bed, an intravenous injection of pentothal is administered. The patient is placed on the operating table in the sitting posture and held in that position for 60 seconds after the percaine injection and then, when he lies down, gas and oxygen inhalation is carried out by the McKesson apparatus.

"**Technique.**—The patient having been placed in the high Trendelenburg position, a paramedian incision, extending from the crest of the pubes to an inch or more above the umbilicus, is made on the right side $\frac{1}{2}$ in. distant from the middle line. The sheath of the right rectus is incised, and the muscle displaced outwards. The peritoneum is divided about $\frac{1}{2}$ in. to the right of the middle line throughout the length of the incision, and a self-retaining retractor inserted. A rapid survey of the abdominal and pelvic cavities is made with a view to ascertaining whether extramural spread of the disease exists or not. Especial search for plaques and metastases should be made in the peritoneum of the pelvic floor, along the origin of the pelvic mesocolon, in the mesocolon itself, in the paracolic glands, and in the glands grouped at the bifurcation of the left common iliac artery. The existence of metastases or plaques in the situations is not necessarily a bar to operation, provided that they either do not extend beyond the field of operation or have not penetrated the peritoneum covering them. When the peritoneum has been penetrated so that the surface of the growth is exposed, even if there be only a single plaque present, operative interference is inadvisable, because in these circumstances general peritoneal carcinomatosis rapidly ensues.

"In the absence of contra-indications, the operation should be proceeded with as follows: The intestines having been packed away in the upper abdomen and retained there by a large swab or towel, the pelvic colon is freed from any existing adhesions so that it can readily be drawn through the wound. The root of the pelvic mesocolon is then rendered prominent by grasping the middle of the pelvic colon and drawing it slightly upwards and towards the pubes. The root of the mesocolon is ligatured *en masse* by passing an aneurysm-needle behind the inferior mesenteric vessels immediately below the point where the artery gives off its first colic branch. Unless the mesocolon contains an excess of fat, the position of the first colic branch can be readily seen. When the artery cannot be seen, the mesocolon should be ligatured at the level of the bifurcation of the aorta, a point well below the origin of the branch. At the level of the bifurcation of the aorta the left ureter is situated about $\frac{1}{2}$ in. to the left of the inferior mesenteric artery, but when the latter crosses the left sacro-iliac synchondrosis the ureter lies in close contact with it, and might easily be included in the ligature should the latter be placed at a lower level than indicated. It should never be necessary to expose the inferior mesenteric artery by incising the peritoneum over it, as this procedure may be attended by free bleeding from the colic veins, thus obscuring the view and embarrassing the operator. Ligature of the inferior mesenteric artery, as the first step in the operation, ensures a bloodless field during the whole of the pelvic portion of the operation, and is therefore essential.

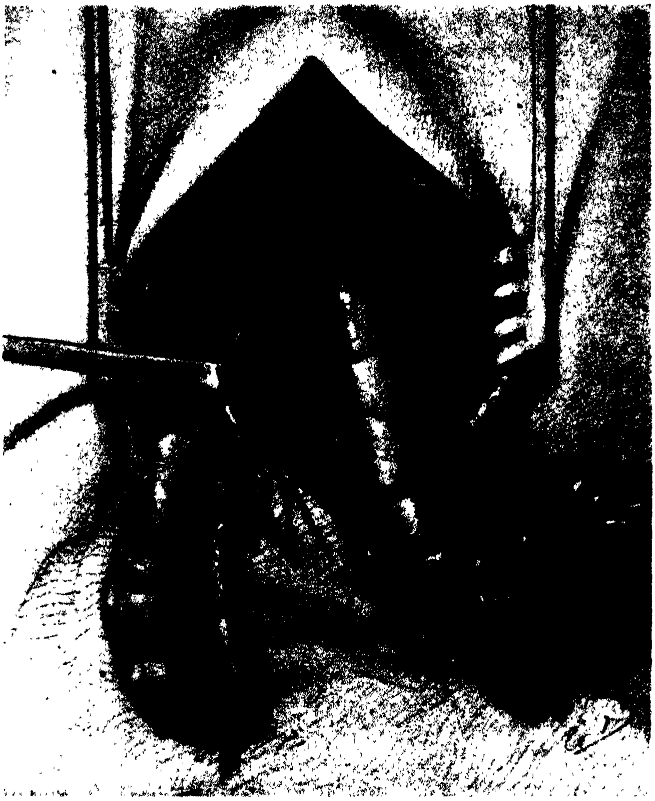

Fig. 540.—Abdomino-perineal resection of rectum : freeing iliac and pelvic colon. The ureter is being drawn aside. The colon is frequently divided later in the operation.

" A second ligature is placed about ½ in. below the first in order to control venous bleeding from the distal part of the mesocolon when the latter is divided. The pelvic mesocolon is now completely divided between the two ligatures, and then the peritoneum on both sides of the origin of the mesocolon is incised downwards as far as the promontory of the sacrum. (Fig. 540.) When this is being done on the left side, the position of the left ureter should be carefully ascertained, so as to avoid injuring it. When the peritoneum has been divided on either side down to the promontory of the sacrum, the loose cellular space between the sacrum and the mesorectum is exposed to view. By thrusting the fingers of the left hand into this space the terminal portion of the pelvic colon and the rectum can be readily stripped from the anterior surface of the sacrum as far as the sacro-coccygeal articulation. (Fig. 541.) At the latter point the fascia propria of the rectum is closely adherent to the periosteum of the lower border of the sacrum, and cannot be stripped from it, indicating that the level of the sacro-coccygeal articulation has been reached.

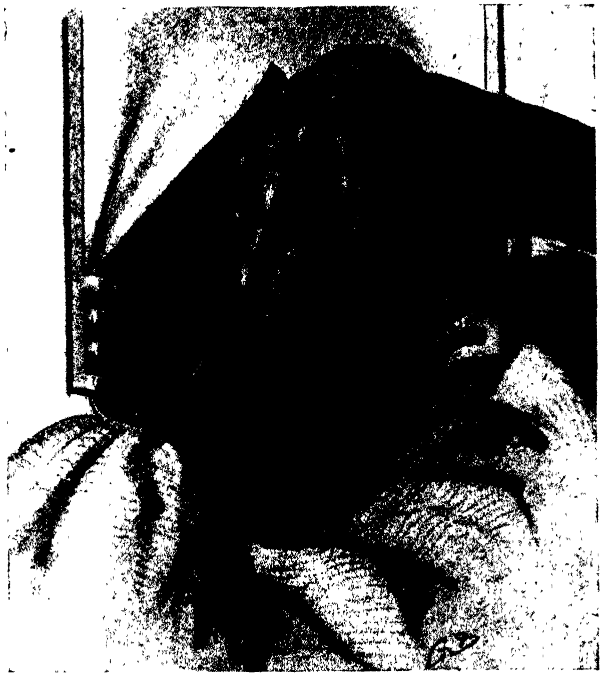

Fig. 541.—Abdomino-perineal resection of rectum : clearing tissues from concavity of sacrum from above.

" Occasionally one or two strongly resistant processes of dense connective tissue bind the fascia propria to the sacrum. These should be divided with scissors rather than torn asunder, lest troublesome bleeding result from laceration of one of the presacral veins to which they may be adherent.

" The left hand is now introduced into the presacral cavity and the rectum gently pressed forwards and upwards in order to raise and render prominent the peritoneum lining the lateral walls of the pelvis. The peritoneum thus raised is divided forwards, on either side, parallel with the brim of the pelvis, and just below the level of the ureters, which must be carefully protected from injury. The incisions in the peritoneum are carried forwards until they meet anteriorly behind the base of the bladder in the male or the upper part of the vagina in the female.

"The rectum is next detached from its anterior connexions. In the male there is a stratum of loose areolar tissue between the fascia propria and the layer of the recto-vesical fascia that binds the vesiculæ seminales to the base of the bladder. If this line of cleavage is found the separation of the rectum down to the upper border of the prostate is readily accomplished. Great care should be taken not to open up the space containing the vesiculæ seminales, as then the dissection is rendered extremely difficult and the vesiculæ may be injured. In the female the separation of the rectum from the posterior wall of the vagina presents no difficulty. As soon as the rectum has been freed, posteriorly as far as the sacro-coccygeal articulation and anteriorly as

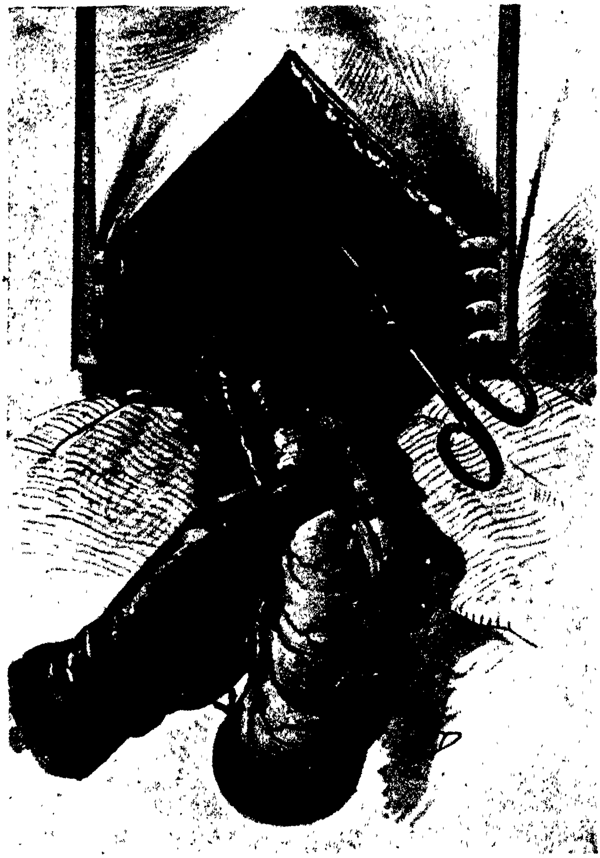

Fig. 542.—Abdomino-perineal resection of rectum : dividing lateral ligaments down to levator ani muscle.

Scissors should be applied near the pelvic wall. The bowel has been separated from the prostate anteriorly.

far as the upper border of the prostate, the lateral attachments of the bowel are brought into view. These consist on either side of a broad vertical band of dense connective tissue, varying from 2 to 3 in., which extends forwards and outwards from the lateral aspect of the rectum to the wall of the pelvis at the point where the ureter enters the base of the bladder. These bands, the lateral ligaments of the rectum, must be completely divided down to the upper surface of the levatores ani muscles. (Fig. 542.) In the substance of the ligament the middle hæmorrhoidal artery is found and is of course divided, but it is seldom of sufficient size to require a ligature.

" When the rectum has been isolated, by severing its connexions above the pelvic diaphragm down to the points indicated, the pelvic colon is divided a hand's breadth from the termination of the descending colon. A broad-bladed crushing clamp (Miles's pattern) is applied to the bowel at this point and left on for a couple of minutes. (Fig. 543.) A stout ligature is applied at either end of the crushed area, and the crushed part of the bowel is divided with a knife between the ligatures. The ends of the divided bowel are protected by tying a piece of rubber tissue firmly over them. The proximal end is laid aside for subsequent use in establishing colostomy. The distal end is pushed downwards in the hollow of the sacrum until it lies in contact with the sacrococcygeal articulation, where it can be readily reached during the perineal portion of the operation. The remainder of the pelvic colon is then crowded into the hollow of the sacrum preparatory to re-establishing the peritoneal floor of the pelvis.

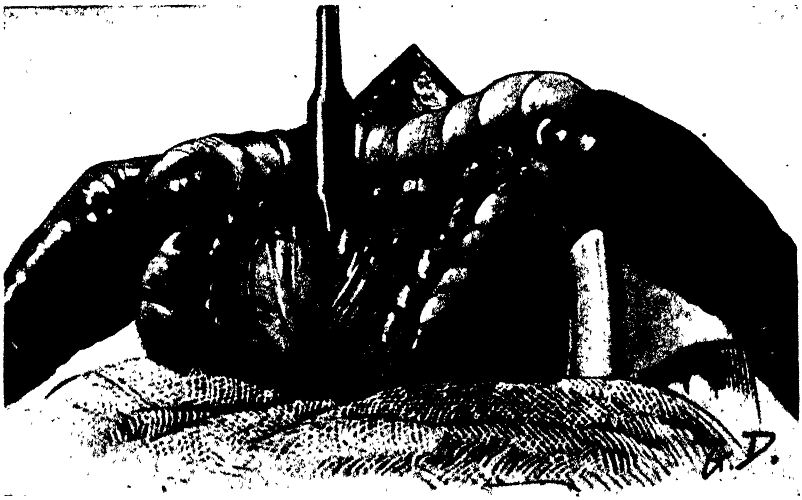

Fig. 543.—Abdomino-perineal resection of rectum : crushing iliac colon at point selected for division.

" Since the whole of the peritoneum lining the floor of the pelvis has been removed, it is impossible to close the gap by dissecting up the peritoneum from the lateral walls of the pelvis. In the male, sufficient peritoneum can be obtained from the bladder completely to close the gap by loosening it and drawing it backwards so that it can be sutured to the stump of the pelvic mesocolon. The margins of the bladder-flap are sutured to the edges of the peritoneum at the pelvic brim, care being taken not to include the ureters in the suture. (Fig. 544.) In the female, the peritoneum requisite for filling the gap is obtained by dissecting up the inner layers of the broad ligaments and suturing them together in the middle line. It is of the utmost importance that the peritoneum forming the new pelvic floor should be intact, so that, in those cases in which the peritoneum is unduly thin and likely to tear, the suture line should be reinforced by an omental graft.

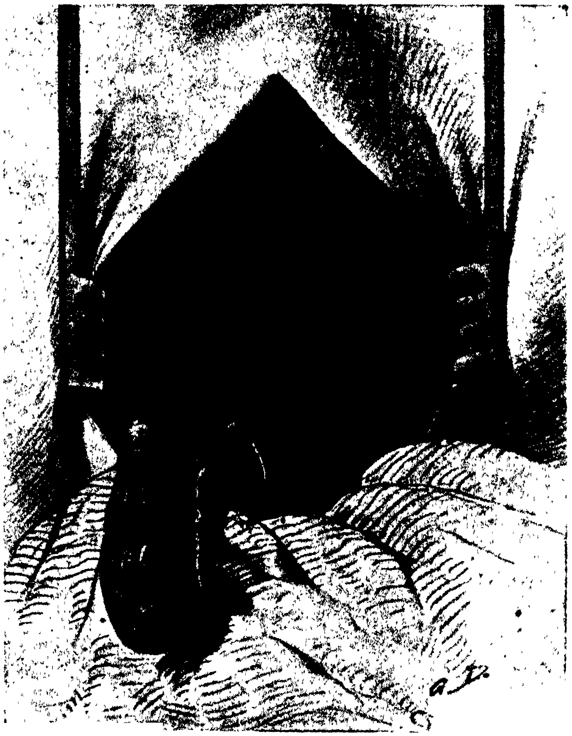

Fig. 544.—Abdomino-perineal resection of rectum : remaking pelvic floor.
Note use of peritoneal flap from the bladder.

" The peritoneal floor thus formed differs from the normal in that it is situated at the level of the pelvic brim. Consequently, as the peritoneum sinks into the pelvis to form a new recto-vesical pouch, a drag is exerted upon the peritoneum of the right iliac fossa to which the terminal portion of the ileum, immediately before it enters the cæcum, is often adherent. As a result, a sharp kink in this part of the ileum may be created, and may cause obstruction. Before the abdomen is closed, therefore, the ileum should be freed from adhesions near its entry into the cæcum.

" The abdominal portion of the operation having now been completed, all that remains to be done, before closing the abdomen, is to establish the colostomy. For this purpose a circle of skin, 1½ inches in diameter, is excised, the centre of the circle corresponding with the junction of the outer and middle thirds of a line drawn from the left anterior superior spine of the ilium to the umbilicus. A stab incision an inch long is then made in the centre of the circle through the whole thickness of the abdominal wall. Through this opening the proximal end of the pelvic colon is drawn as far as possible, and fixed in position by two silkworm-gut sutures. The abdomen is then closed in layers, and a temporary dressing applied.

" The Trendelenburg position of the operating-table having been dispensed with, the patient is placed in the right or left lateral and semi-prone position, with the thighs flexed upon the abdomen and the buttocks drawn well over the edge of the table. The perineum having been thoroughly cleansed, the anus is closed by a purse-string suture. A transverse incision 3 in. long is made at the level of the sacrococcygeal joint. From the centre of this an incision is carried in the internatal cleft to a point about an inch from the posterior commissure of the anus. From the latter point a horseshoe-shaped incision is made so as to include a wide area of skin on either side of the anus, the extremities of the horse-shoe terminating at the level of the central point of the perineum. Finally, a transverse incision is carried from one extremity of the horseshoe to the other. The lateral skin-flaps, thus marked out, are dissected up, and the coccyx is removed. The fascia propria of the rectum, at the point where it is adherent to the periosteum at the lower border of the sacrum, is cut through, and the space widened on either side, so that free access is gained to the cavity containing the isolated pelvic colon and rectum. The coccygei muscles are divided outwards as far as the edges of the great sacrosciatic ligaments, and the occluded end of the pelvic colon is seized and drawn through the opening until the whole of the isolated bowel is delivered externally. (Fig. 545.)

" Provided that the isolation of the rectum has been carried out as far as the levels indicated above, there is no difficulty in withdrawing the whole of the loosened part of the bowel, and then the base of the bladder, the vesiculæ, and the prostate come into view. The levatores ani muscles are also displayed, and can be divided close to their origin from the wall of the pelvis. All that now remains to be done is to deepen the incisions in the perineum and include as much of the ischiorectal fat as possible. The inferior hæmorrhoidal arteries are divided in this dissection, and require a ligature. The line of cleavage between the capsule of the prostate and the anterior wall of the rectum is then carefully sought and the dissection made through the loose cellular tissue found there. When the growth has penetrated the wall of the bowel and is found to invade the prostatic capsule, the capsule must be removed. In the female the rectum can be readily stripped from the posterior vaginal wall unless the latter has been invaded, in which case the posterior vaginal wall must be freely excised. Finally, the anal canal is dissected from its perineal connexions, care being taken not to injure the membranous urethra.

" The removal of the rectum and the greater part of the pelvic colon leaves a huge cavity which cannot possibly be obliterated by sutures. Hence, healing by primary intention is out of the question, and the cavity must be left to granulate. After all bleeding vessels have been ligated the cavity is swabbed out with a strong solution of perchloride of mercury (1 : 500), and then lined throughout with green protective or rubber tissue. Into the cavity thus lined a mass of sterile gauze is packed to support the new pelvic floor (Fig. 546), which consists of peritoneum only, and might easily be torn through by the weight of the intestines above it unless adequately supported.

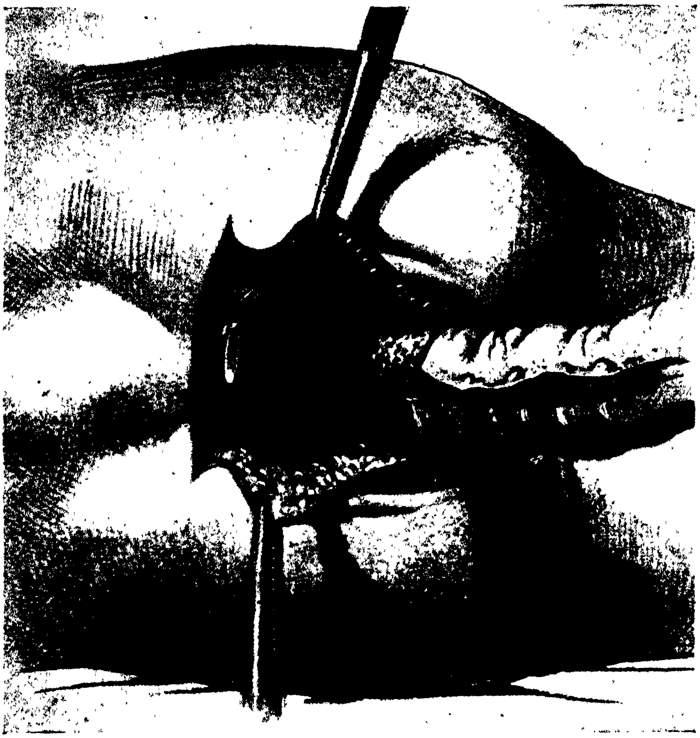

Fig. 545.—Abdomino-perineal resection of rectum : removing liberated iliac and pelvic colon through perineal wound. The right lateral position may be chosen.

The levatores ani are divided at this stage, and the prostatic capsule separated from the bowel.

" The skin-flaps are replaced and sutured in position, but the remainder of the perineal wound is left open to provide free drainage. The patient is then turned on to his back and a self-retaining catheter is inserted into the protruding part of the colon, so as to provide for the escape of flatus and to enable saline solution to be introduced into the colon in case of need.

"**Postoperative treatment.**—Directly after the completion of the operation a blood-transfusion (500 c.c.) should be administered, preferably by the drip method, 20 to 30 drips per minute as required. When the blood transfusion has been completed, intravenous glucose saline infusion by the drip method is continued for 48 hours. During the first 48 hours after the operation nothing whatever should be given by the mouth, the fluid content being maintained by the intravenous infusion. The patient's mouth must be frequently washed out but he must not be allowed to swallow fluid lest acute gastric dilatation be produced. As soon as 48 hours have expired, small drinks at 2 or 3 hourly intervals may be allowed. There is no doubt that this is the best means of combating postoperative shock. As soon as the patient has been placed in bed, the foot of the bed is raised and an electric heat-cradle is fitted, the temperature being carefully regulated. The perineal wound is dressed for the first time 48 hours after the operation. When the gauze-packing and green protective have been removed, the cavity of the wound is irrigated with (1) hydrogen peroxide (10 vols.)

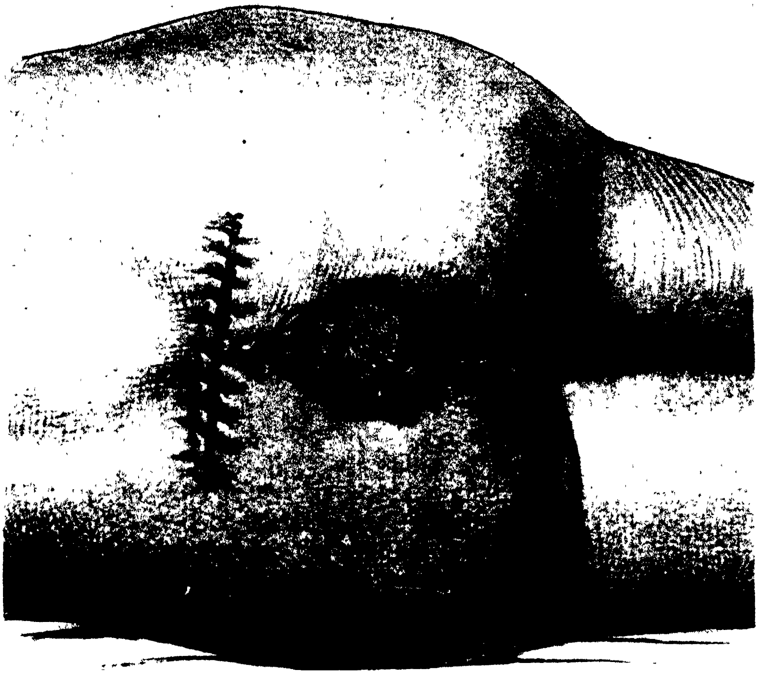

Fig. 546.—**Abdomino-perineal resection of rectum : perineal wound closed. A mass of gauze in a bag of green protective or rubber tissue is used to support the pelvic floor and is shown lying in the wound.**

one pint, followed by (2) perchloride of mercury (1 : 500) one pint, followed by (3) two pints of normal saline solution. Irrigation with these solutions is carried out twice daily during the first week, after which period a solution of iodine (2 drams to the pint) is substituted.

"On the morning of the fifth day an enema is administered through the colonic stoma and on the following day a saline purgative is given. The colon wash-out should be repeated daily so as to ensure an action of the bowels without aperients.

"At the expiration of a week any excess of bowel forming the colonic stoma should be removed. This can be done with the electric cautery, no anæsthetic being necessary. Subsequently digital dilatation of the stoma should be carried out until all tendency to contraction has ceased.

"**Complications.**—The packing effectually prevents venous oozing from the sacral cavity, but shock may be severe. Occasionally there is temporary retention of urine. Peritonitis does not occur, but there is a definite risk of small-intestine obstruction, either by the drag of the new pelvic floor as described above, or by adhesions to the suture-line in the pelvic floor. Pulmonary complications are rather frequent, but their incidence has been much reduced since spinal anæsthesia with gas and oxygen has become the method of choice."

Postoperative mortality.—Miles, from an experience of 406 radical abdomino-perineal operations, reported* marked reduction in the mortality rate in successive series of cases extending over a period of twenty-four years. He attributed the decline to three main factors : (*a*) the employment of more suitable methods of inducing anæsthesia, (*b*) the estimation of cardiac energy, when assessing operability, by the Moots-McKesson '*pressure-ratio-percentage*' test, and (*c*) the adoption of blood-transfusion as a routine measure immediately after the completion of the operation.

In the earliest series of 65 operations in which either ether or chloroform was used for inducing anæsthesia the mortality was 37 per cent. In the next series of 57 operations, performed under spinal anæsthesia supplemented by gas-and-oxygen inhalation, the mortality fell to 12·8 per cent., but when the series had been extended to 126 operations it was found that there had been 21 deaths, resulting in a mortality of 17 per cent. In the next series of 153 operations, in which a caudal block of a 2 per cent. solution of novocain (30 c.c.) supplemented by intrathecal stovaine was employed, there were 15 deaths, the mortality rate thus falling to 9·8 per cent.

In another series of 65 operations the method of inducing anæsthesia was the same as in the preceding series, but in addition, blood-transfusion (500 c.c.) was given as soon as the patient had returned to bed. There were 5 deaths, the mortality thus being still further reduced to 7·6 per cent. In the latest series of 55 operations there have been 7 deaths showing an operation mortality of 12·3 per cent.

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* *Proc. Roy. Soc. Med.*, May, 1931, xxiv, 989.

OTHER OPERATIONS WHICH MAY BE EMPLOYED

For the removal of the whole rectum and pelvic colon many other combined operations have been introduced, either as one- or two-stage proceedings. So far as removal of the diseased tissue is concerned no new principle is involved, but the technical details are ingenious and, in the hands of their originators, have often yielded very good results. One of the best appears to be the procedure described and illustrated by Frank H. Lahey and Richard B. Cattell.* A technique has also been devised by which two operators work simultaneously from the abdomen and the perineum. This plan is recommended by Sir Hugh Devine and is now being practised by many surgeons.†

Local excision.—Simple local removal of a small growth is justifiable only for diagnostic purposes, although it must be allowed that such limited interference has sometimes been followed by freedom from recurrence over a period of many years.

In dealing with small and presumably early growths the question of radium is bound to arise. Unfortunately this powerful remedy has proved very disappointing in this field. Almost all British surgeons are now agreed that such growths should be subjected to operation. Some surgeons, and notably Ernest Miles, make the early growths an opportunity for the most complete and radical operations, whereas others look upon them as an indication for some type of conservative removal. Recent investigation suggests that it is the type of growth more than its extent which has the greatest bearing on the ultimate result. Unfortunately, except in the very early cases, it is not possible to determine precisely the group to which the growth belongs until the removed specimen can be critically examined, so that this knowledge is more a guide to prognosis than to actual treatment. To emphasize the wisdom of the more extensive operations, it may be mentioned that Dukes found a second, and often unsuspected, growth higher in the bowel in 4 per cent. of cases.

Lower conservative resection.—This operation is conducted from the perineum and consists in the removal of a complete section of the rectum, followed by restoration of the canal by direct end-to-end suture, without removal of the levatores ani or the sphincters. Such an operation is only justified when all the evidence points to an early growth of the papillomatous type (" A " group). In most of the cases hæmorrhage has been an early symptom. On examination, the growth has not been larger than 3 or 4 cm. across, and it has been possible to move it from side to side with the examining finger, and to demonstrate that it moved up and down when the patient strained, these criteria indicating that the growth had not deeply infiltrated the wall of the bowel. Of course it is essential that there should be no suspicion of secondary deposits. In these circumstances it has not been considered necessary to carry out an abdominal exploration, and for the success of the operation colostomy is not essential, although it has sometimes been employed. The section of rectum is removed, together with all the pararectal tissues and lymphatic glands inside the levatores ani, which are preserved, whereas in all other types of operation, these muscles are deliberately removed. The patient is prepared so that the rectum is as empty and as clean as possible. The left lateral position is most convenient.

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* *Amer. Journ. Surg.*, 1935, xxvii, 201.

† *Brit. Journ. Surg.*, 1937, xxv, 351.

An incision is made commencing at the left side of the base of the coccyx and is continued forwards as far as the posterior margin of the anus ; from just beyond the tip of the coccyx it follows the median sulcus. This incision is deepened and carried through the posterior raphé of the levatores ani muscles until the rectum is exposed inside its muscular bed. The bowel *with the whole of its surrounding pararectal tissues* is then completely separated downwards as far as the upper border of the internal sphincter and upwards as far as the disease demands. This separation can be almost entirely carried out with the finger by blunt dissection but at the lowest part the rectum bulges anteriorly more than is usually anticipated. At this point it may have to be cleared from the surrounding structures with the scissors. In most cases securing a sufficient margin of healthy bowel above the growth involves opening the recto-vesical or Douglas's pouch and dividing the bowel two or even three inches above this point. After this amount has been removed the ends are approximated and are carefully sutured with catgut. (Figs. 547, 548.) In every case it has been possible to get the ends into apposition without tension, but this results in straightening out the rectum so that it passes directly downwards, from the pouch of Douglas or recto-vesical pouch, towards the anus instead of following the curve of the sacrum and coccyx. The suture of the anterior and lateral walls is usually easy and satisfactory, and in carrying out this step a certain amount of tissue is turned into the lumen so that when it heals it forms a ring-like shelf on the anterior and lateral walls. The posterior wall, on the other hand, is not inverted to the same extent, as there is seldom enough bowel to spare for this purpose. After the anastomosis is completed the median raphé between the levatores is carefully drawn together by interrupted sutures. A small drain of rubber tissue is left behind the rectum and is brought out of the wound, and the skin and subcutaneous fat are securely sutured over the muscles. In order to avoid tension in the rectum from the accumulation of flatus or blood and mucus, a rubber tube (½ in.) is passed through the anus and is left there for four or five days. The bowels are kept quiet for four days, after which liquid paraffin is given by the mouth, with small doses of cascara or confection of senna. If necessary, bowel action may be encouraged by a small glycerine enema. There is usually some little infection of the wound and there may be a slight fæcal fistula, but the latter almost always closes spontaneously in a few weeks. The functional results have been most satisfactory. Of seven patients who survived the operation for more than five years, three died without recurrence at 9, 8½ and 8 years later respectively. Four are alive and well (1942), with good rectal function, 20½, 20 and two 16 years after operation.*

Conservative operation conducted entirely from above : The " Upper Conservative Resection." —This method is only suitable for growths in the highest part of the rectum which would ordinarily be

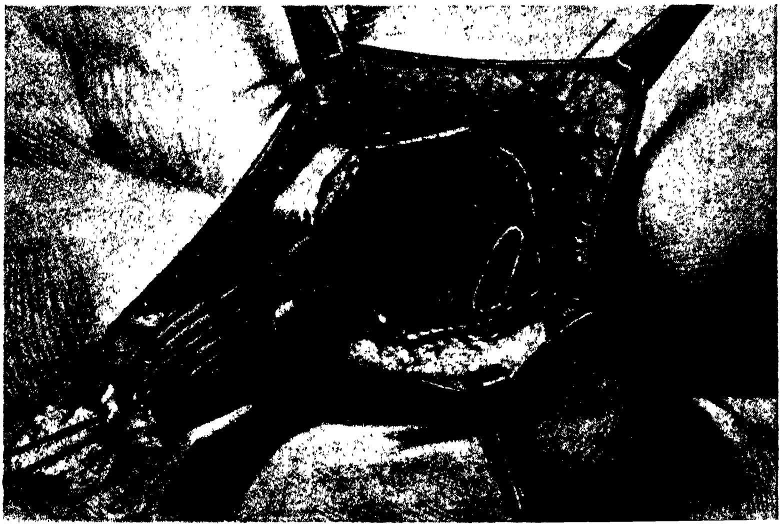

Fig. 547 —Showing the principal steps of the operation of posterior conservative resection of the rectum.

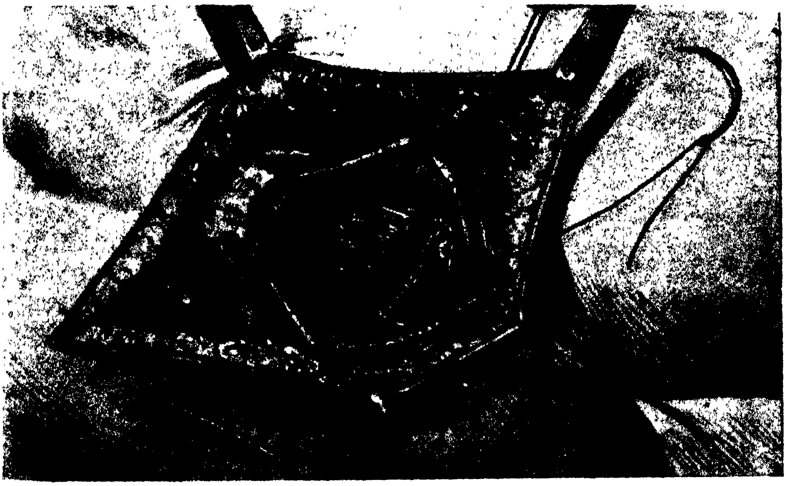

Fig. 548.—Suture of the bowel in operation of posterior conservative resection.
(Reproduced by permission from *Acta Chirurgica Scandinavica*.)

dealt with by the abdomino-perineal method. In many cases it seems a dreadful mutilation to have to take away the unaffected lower rectum with its wonderful sphincteric mechanism. When two or three inches of the rectum below the growth together with the pararectal tissue can be removed, it eliminates the risk of recurrence from downward extension. As this can often be done by freely removing the pelvic peritoneum and mobilizing the bowel as it lies inside the levatores ani, it makes this operation quite feasible. The method must always be a two-stage proceeding.

At the first intervention a careful exploration is made to ascertain that there is no extension or dissemination. A dysfunctioning type of colostomy is then made at the upper part of a voluminous sigmoid or in the transverse colon. By this means the distal bowel with the growth may be thoroughly cleansed. At the second operation the midline incision which has been employed for the exploration is reopened. A transverse incision from one anterior superior spine to the other, freely dividing the abdominal muscles, also gives an admirable exposure. With the patient in the high Trendelenburg posture, the growth is defined and is encircled by an incision designed to cut away the whole of the bottom of the recto-vesical pouch. When the extra-peritoneal cellular tissue is exposed, separation is carried out as far from the bowel as possible, just inside the levatores ani, and almost as low down as the pelvic diaphragm. This step is facilitated by the mobilization of the bowel from the front of the sacrum. By this means a sufficient margin of bowel below as well as above the growth —together with the peri-rectal tissue, the meso-rectum, and the pelvic meso-colon—can be removed. End-to-end union by direct suture is then made ; this step is difficult, but the dysfunctioning colostomy makes it reasonably safe. Interrupted sutures have to be employed for the greater part of the anastomosis and it is difficult to make the union accurately. The main vessels are easily secured as the meso-sigmoid is divided, but the surgeon must assure himself by careful examination rather than by preconceived knowledge of anatomy that the blood supply is adequate. A few spouting vessels in the divided lower end will require ligature. Before the anastomosis is completed a rubber tube the size of the thumb is passed into the lower end of the divided rectum and brought out through the anus. This may be accomplished by tying this tube to a piece of gauze which has been packed into the rectum from the anus as a first step in the operation before the abdomen is opened. As the gauze is withdrawn the tube follows it through the anus. The upper end of the tube is then passed into the bowel above the site of anastomosis and the anterior part of the latter is completed.

The pelvic cellular tissue may be partially covered by drawing the cut edges of the peritoneum together and by stitching its posterior cut edge to the bowel above the anastomosis. In the female the uterus can sometimes be turned back, or in either sex a voluminous omentum may be packed into the pelvis over the raw area. If none of these aids is available it is safer to pack gauze over the exposed raw area and to protect the small intestine from adhesion by covering the gauze with strands of rubber tissue. If gauze is not used, a softened rubber tube must be placed in the pelvis. All drains are brought through the lower end of the abdominal incision, which is carefully closed by layer suture with some additional through-and-through silkworm stitches. As a last stage in the operation the rectal tube should be anchored with a silkworm suture to the margin of the anus.

For the first few days the patient is nursed in the Fowler position. If the pelvis has been packed with gauze this should be left *in situ* for at least four days and should be removed piecemeal on two or three days. A tube left in the pelvis may be removed at the end of a week, and if the rectal tube is well tolerated it is best left in for a little longer. No attempt should be made to close the colostomy until the abdominal incision is soundly healed—probably a month or six weeks after operation. Sometimes a small fæcal fistula forms but, if the bowels are kept acting, it usually heals readily.

This may be a difficult and trying operation, especially in bulky males. The wide pelvis of the multiparous female renders the approach and manipulation easier. The principal risk is of pelvic cellulitis but that has certainly been lessened since the advantages of the dysfunctioning colostomy and adequate preparation have been appreciated. In a limited series of cases the results, immediate and remote, have been very encouraging and the operation deserves serious consideration by those charged with the responsibility of dealing with the type of case in which it might be employed. (*See also* pp. 957–959, Vol. I.)

Abdomino-anal conservative method.—In like cases, and even those further advanced, some Continental surgeons have practised and advocated what they designate a " pull-through method." The lower part of the pelvic colon, with its mesentery, and the rectum are separated from their attachments by the abdominal route. The separation is continued from above inside the levatores ani almost to the anus, and the operation is then completed from below by dissecting up the mucous membrane from the anal canal until the plane of separation from above is reached. The bowel with the growth is then withdrawn through the dilated anus, cutting it away at a point well above the growth and attaching the margins of the bowel to the external sphincter. This operation is conducted after a preliminary colostomy, and very great care is taken to sterilize the lower bowel as far as possible. The surgeon must take great care to select a point for the division of the pelvic colon which will secure three essentials : (1) a site sufficiently far away from the growth ; (2) a site which will allow a sufficiency of bowel to reach to the anus without tension, and (3) an area which is secured of its blood supply right up to the point of section.

For this method to be a success it is important that the growth should not be too bulky, for it must be drawn through the dilated anal canal without either tearing the latter or damaging the growth. The suture of the mucous membrane of the colon to the edge of the anal margin must be most accurate, and the greatest care must be taken to ensure that this stage of the operation is not spoilt by sepsis. The bowel is divided in sections, each cut portion being sutured to the anus before the next section is divided.

Epithelioma of the anal canal.—Growths of the anal margin are of the nature of squamous epithelioma and often yield to radium-therapy. If an operation is required, a very small growth may be dealt with by excising only a part of the circumference of the anus, but it is usually necessary to excise a wide area of skin around the growth, together with the anal canal and lowest part of the rectum. In some cases the cut end of the rectum can be brought down and stitched to the adjoining skin, but even if this cannot be done, or if there is subsequent retraction, the result is usually quite satisfactory provided bougies are regularly used to guard against stricture. If the excision has to be very wide, because of the extent of the growth, it is better to combine the removal with left inguinal colostomy. It must be remembered that the lymph from this region drains to the inguinal glands so that in all cases where the growth actually invades the skin of the anus the groin glands on both sides should be subsequently removed. This should also be done even after successful treatment of the primary growth by radium.

POSTOPERATIVE COMPLICATIONS

These are for the most part such as may follow any major abdominal or pelvic operation.

Urinary infections are not infrequent and may have serious consequences, especially in men. Their incidence is probably due to the fact that the mechanics of the bladder are upset by the removal of its posterior support while, in addition, there may be some interference with its nerve supply. As a result, patients may pass urine but without properly emptying the bladder, so that there is apt to be a considerable residue. Retention is also common, and the repeated use of the catheter is only too likely to produce infection. To avoid these difficulties a catheter may be tied into the bladder at the outset. The St. Mark's surgeons make this a routine, and connect the catheter to an apparatus, devised by Cuthbert Dukes, which seals it with a reliable antiseptic solution and is so arranged that the bladder can be emptied and irrigated at regular intervals without disturbing the patient. As many patients escape retention altogether, I do not catheterize as a routine but take great care to see that the amount of urine passed is sufficient. Even when some difficulty exists, the patients can often be encouraged to micturate with success and a catheter may never be required. Should there be retention, the catheter is passed every twelve hours, or once in twenty-four hours if it is only a question of residual urine. If a catheter has to be passed or tied in, the instrument is washed through twice daily with oxycyanide of mercury, 1 in 8,000, or a saturated solution of boracic acid. In some few cases urinary difficulty is due to enlargement of the prostate. If the function is not soon restored by the use of the catheter, a supra-pubic drain is inserted by means of the Morson trochar, and the prostate is dealt with *secundum artem* when convalescence from the rectal operation is sufficiently advanced.

Slight infection of the perineal wound is not uncommon and is treated on ordinary lines. In severe infection the wound must be completely laid open at once. The large gaping cavity can then be effectively irrigated by means of a large jug delivering a voluminous stream of mild antiseptic, rather than with a small irrigator or syringe.. The sulphanilamides are popular at the moment, but chemotherapy should be checked by bacteriological findings. The main indication is to lay open the wound, to irrigate frequently and to pack lightly with gauze in the intervals, while the head end of the bed should be elevated to promote drainage. As soon as the wound is granulating in a healthy fashion, secondary suture may be considered, but it is surprising how readily these large wounds close by granulation alone.

Persistent sinus in the perineal wound may be most troublesome. It may be kept up by some slough which is slow in separating, or may result from infection of the bared end of the sacrum, or it may be due to a foreign body inadvertently left in the wound. When the discharge is largely mucous, or fæcal and mucous, the lower cut end of the bowel has not completely healed or has re-opened. The bowel must be washed out from the colostomy or *vice versa* and this should be done at regular intervals. When there are two or three skin openings they should be connected by incision and the wound explored. But whatever the cause, such sinuses may be most difficult to cure and have sometimes persisted in spite of the most drastic measures to bring about healing.

Obstruction of the small intestine may result from a knuckle escaping between the sutures used to close the pelvic peritoneum or from adhesion of a loop to the bottom of the pelvis. When the diagnosis of mechanical obstruction has been made there must be no temporizing, and the abdomen should be re-opened without delay.

Among late sequelæ two conditions demand notice. The first is due to the **accumulation of mucus** in the blind end of the bowel below the colostomy. This seldom occurs until two or more years after operation, but the symptoms are very characteristic. The patient is troubled by a sensation of fullness in the perineum and this is followed by a feeling as though something wanted to burst away from the site of the original anus. In some cases an abscess has actually formed in the perineum and on incision an accumulation of pus and mucus has been evacuated. The proper treatment is to wash out the lower bowel from the colostomy. For this purpose a catheter should be passed down as far as possible from the lower bowel opening. If nothing comes away, a strong alkaline solution may be used to dissolve the mucus, or some olive oil may be run in and followed after a few hours by hot irrigations. Heat may also be applied to the perineum and the patient be directed to lie face downwards for some hours at a time. This treatment is nearly always successful, and recurrence can be prevented by occasional irrigation of the blind segment of bowel.

Hernia through the perineal wound is a rare sequel. It usually appears just opposite the end of the sacrum or just by its side. As a rule, the patient makes little complaint and the support of a pad and bandage is all that is required. If operation is necessary, fascial suture (Gallie's method) should be employed (p. 1046).

OPERATIVE MORTALITY AND LATE RESULTS

Taking an average cross section of the results in the hands of several surgeons dealing with cases of varying severity and a consequent variety of operations, the mortality is probably between 10 and 15 per cent. By very careful selection of cases and especial skill, some surgeons have been able to record a much lower mortality, and fortunate runs are proverbial. Improvements in technique are not always immediately followed by a lower mortality for, as a result, the possible benefits of operation are usually extended to a greater number of more advanced cases. In consequence, the operability rate and the mortality are often in inverse ratio. The mortality bears less relation to age than might be expected, for thin, rather wizened old people often come through the ordeal surprisingly well. The risk is certainly greater in the male and especially the big bulky plethoric type. It is also proportionate to the height of the growth in the rectum, and in all circumstances the later stages of the disease prove more dangerous. Local sepsis, with its attendant risks, accounts for a considerable proportion of the deaths ; urinary infections are also a considerable factor. *Of patients who recover,* about 50 per cent. survive over the five-year period without recurrence. An analysis of the pathological condition of the survivors goes to show that the " A " cases, the papillomatous type of growth without infiltration, give the highest proportion of five-year successes—sometimes quoted as nearly 100 per cent. As with cancer in general, the secondary involvement of the lymph glands has the most direct bearing on the likelihood of recurrence.

But the after-results need not be too carefully scrutinized, for operative intervention holds out the only hope of cure and promises the greatest amount of relief, even though only for a limited period. Without doubt, excision is by far the best palliative in cancer of the rectum and a patient who has to put up with colostomy is infinitely more comfortable if the carcinomatous rectum is also removed, even though recurrence or dissemination is not long delayed. As with cancer in general, except in the presence of unequivocal dissemination, the surgeon must not be easily deterred.

CHAPTER XXV

OPERATIONS FOR NON-MALIGNANT STRICTURES AND TUMOURS OF THE RECTUM, HÆMORRHOIDS, FISTULA, PROLAPSE AND PRURITUS

By J. P. LOCKHART-MUMMERY

STRICTURE OF THE RECTUM (NON-MALIGNANT)

SIMPLE strictures of the rectum may be divided into congenital, spasmodic and inflammatory.

Congenital stricture.—The stricture may be a complete obstruction or merely a slight fibrous ring. Children born with atresia ani, who have never had any form of plastic operation, may have very little stricture where the congenital fault is merely a diaphragm, but where some definite portion of the gut is missing very severe stricture will almost certainly be present and may be most difficult to deal with. Transplantation of the healthy gut down to the skin at a suitable age will often give very good results.

Spasmodic stricture.—The existence of true spasmodic stricture has been denied by many authors, but there can, I think, be no doubt that it does occasionally occur. Since the introduction of the electric sigmoidoscope some of these spasmodic strictures have been studied. The condition is very rare and the exact cause is not known. It is quite exceptional to find any irritative lesion, such as an ulcer, in the neighbourhood. In a serious case, sympathectomy might be considered

Inflammatory stricture.—The most severe types are due to the deposit of fibrous tissue, a result of some previous inflammation or injury. One of the commonest causes is a septic ulceration following operation on the rectum, or infection from the use of a dirty enema nozzle, etc. These sources of infection have now to a very large extent been eliminated, though before the introduction of antiseptics they were common. However, cases are still seen after parturition and as a complication of severe illnesses. The accidental introduction of hot or caustic fluids into the rectum has been known to cause stricture in several cases. I have seen a very severe stricture result from the injection of paraffin wax for the cure of prolapse. Stricture sometimes follows a bad fistula, or an operation for its relief where this is not properly done.

The worst forms of stricture are very chronic and generally involve a large part of the rectum. There is severe sepsis, discharge of pus and blood, and fever. The history often extends back for many years, and as a rule no definite cause can be ascertained. In a few cases there is a story of gonorrhœal infection, but more frequently there is nothing definite. These cases used to be put down to syphilis, and are still so classified by many authors. Some surgeons argue that a fibrous stricture of the rectum is of luetic origin because the patient has a positive Wassermann reaction, but it need hardly be pointed out that the presence of syphilis in a patient suffering from stricture of the rectum does not necessarily prove it to be due to this cause, and, by universal agreement, none of these strictures can be relieved by anti-syphilitic treatment. Many of these chronic fibrous strictures are due to the disease known as lymphogranuloma inguinale, and are the result of a venereal-virus infection. In men the disease manifests itself usually by sores in the groins, but in women by fibrous stricture of the rectum. Occasionally the stricture also occurs in men. The condition is much commoner in France, Germany and Holland than in this country. All suspected cases should be tested by the Frei reaction. Treatment by neosalvarsan, M. & B. and intravenous tartaric acid is supposed to be effective in a few cases, but the condition as seen by surgeons in this country is generally an end-result of a chronic infection that has continued for many years, and requires surgical measures. The best treatment then is a permanent colostomy.

Treatment of stricture.—Intermittent dilatation, properly carried out with graduated bougies, is of great value, provided the stricture is not too advanced. The bougies should be passed every day or every other day until they go in with fair ease; after this they should be passed at lessening intervals, and eventually the patients are taught to pass their own bougie perhaps once a week. They should be kept under observation for at least a year, as these strictures have a very serious tendency to recur directly dilatation is stopped, and patients are very apt to cease treatment the moment they are comfortable. The fæces should not be kept liquid or too soft by medicines, as the daily passage of a firm stool acts as a valuable dilator.

Internal proctotomy.—This should be reserved for cases where the stricture is low down, i.e. within very easy reach of the finger, and below the peritoneal reflection. The stricture is cut with a blunt-pointed bistoury passed into the rectum, guided by the finger. The cuts are made on its posterior aspect in several places, and then the stricture is dilated with bougies to the desired size. This must be done under the strictest antiseptic precautions or there will be grave risk of setting up severe cellulitis. At the termination of the operation a large hollow vulcanite tube is tied into the rectum for 48 hours, and subsequently the stricture is treated by intermittent dilatation with bougies.

Excision.—In all cases of stricture which are not amenable to proctotomy or dilatation, the best treatment is complete excision of the damaged area of bowel (p. 1137). Where conditions permit, the bowel may be restored by bringing the upper end down and suturing it to the anus. Where, owing to the extent of the stricture, this is not possible, the operation must be terminated by a permanent colostomy. It is a dangerous operation if the stricture is septic, as it nearly always is, but the results are often good. When the stricture cannot be excised, the best treatment is colostomy, which may subsequently be followed by removal. In some cases an excellent result has been obtained by doing a temporary colostomy and then resecting the damaged portion of the rectum and restoring the parts by a carefully planned plastic operation. When this has been successfully achieved the temporary colostomy can be closed. A method that has occasionally been employed successfully is to cut down on the rectum from behind, after removing the coccyx, and then to split the stricture in a vertical direction and sew up the wound in the rectum in the opposite direction over a large-bore rubber tube. When the wound has completely healed and the calibre of the rectum is satisfactory, the colostomy is closed (*see* p. 896, Vol. I).

NON-MALIGNANT TUMOURS

Adeno-myomata.—These curious tumours, which are due to transplants of endometrial tissue on the peritoneum of Douglas's pouch, are only found in women. They may form large tumours invading and obstructing the rectum. Their removal may be a matter of serious difficulty, or indeed, impossible. They have been treated successfully by radium and by oöphorectomy.

Angiomata of the rectum.—These are congenital vascular tumours and are apt to cause serious and often fatal hæmorrhage. Ligature of the main feeding vessels from the abdominal aspect seems to offer the best chance of remedying the condition. If this cannot be done or fails to give satisfactory results, the tumour may be partially coagulated or seared with the diathermy apparatus through a speculum or sigmoidoscope. In very severe cases colostomy may be required.

Fibrous polypi.—These may reach a considerable size and cause distressing symptoms. They can be readily removed with a diathermy snare through an operating sigmoidoscope, or may sometimes be pulled down outside the anus and ligatured off with silk. A good pedicle should be left, as there is often quite a deep dimple on the peritoneal surface of the bowel, and removal too close to the bowel wall may make a hole into the peritoneal cavity.

Adenomata.—These used to be considered non-malignant, but recent research has proved that they are semi-malignant. That is to say, if left alone, a large proportion of them tend in time to become true carcinomata, and for that reason it is important that they should be freely removed and, further, that the patient should be examined periodically for some years afterwards to make sure they have not recurred or others developed.

Small adenomata can be removed with a wire snare, or preferably a diathermy snare, or can be merely nipped away with crocodile forceps. Large adenomata can, when pedunculated, be dragged down and ligatured or burnt away with an electric knife. Adenomata that cannot be thus dealt with require to be excised. If they are very large and have an extensive base, complete excision of the rectum as for carcinoma will be necessary. Sometimes a local excision through a posterior incision after removal of the coccyx is possible, followed by restoration of the rectum (*see* p. 1137).

Adenomatosis or multiple polypi of the rectum and colon.—This curious disease is hereditary and occurs as a dominant factor, attacking most members of affected families regardless of sex. In almost all cases the patients develop cancer at an early age, and so need drastic treatment. The only effectual treatment known at present is complete colectomy and removal of all polypi in the rectum.

Dermoid cysts.—These are met with in two situations near the rectum : (1) Sacro-coccygeal cysts situated between the tip of the coccyx and the skin ; (2) post-rectal dermoids situated between the rectum and the sacrum.

Sacro-coccygeal cysts are often mistaken for some form of fistula, and as they do not respond to the ordinary treatment for fistula they have been the cause of considerable trouble owing to the refusal of wounds to heal. They are true dermoid cysts due to faulty coalescence of the skin during embryonic life. They generally first call attention to themselves by suppurating and causing an abscess just over the coccyx. The proper treatment is to dissect out the whole of the cyst and tracks down to the deep fascia covering the coccyx, and leave the wound to fill in by granulations. Such cysts frequently contain locks of hair.

Post-rectal dermoids are often of considerable size, bulging into the rectum from behind and overlapping it at the sides. They are very difficult to tackle successfully, especially if suppuration has occurred. Unfortunately, they are often mistaken for abscesses and drained, with the result that troublesome suppuration occurs and adds to the difficulty of removal. If they can be removed before suppuration begins they will shell out from their bed, if free access can be obtained. The coccyx should be excised and, with one finger in the rectum to protect the bowel wall from injury, the cyst can be loosened from its attachments and removed intact.

Dermoid cysts are sometimes found in front of the rectum, and in this situation will tax all the ingenuity and skill of the surgeon before they can be successfully removed.

HÆMORRHOIDS

External piles call for operative treatment only when they become thrombosed. They appear at the margin of the anus as smooth, rounded swellings about the size of a pea, or larger ; and, as a rule, disappear within a short time, but may be very large and exceedingly painful. Such cases should be treated by removal of the clot. The skin overlying the swelling is rendered anæsthetic by infiltration with 1 per cent. novocain and cut away, the incision radiating towards the anus. The clot is removed, and an antiseptic dressing applied, the small wound being left open to granulate, which it should do in the space of a few days. The removal of the clot gives immediate relief from pain.

Internal piles.—The standard operation for the removal of internal piles is now the *ligature operation* or some modification. Such procedures as the clamp and cautery and Whitehead's operation have been discarded. The ligature operation, if properly performed, should be completely successful and should not be followed by recurrence or accompanied by any serious discomfort, but much depends on the skill of the operator.

The operation is performed as follows: The patient is thoroughly prepared, first of all with a dose of castor oil, which should be given on the morning of the day before operation; a dose of opium is given the night before the operation, and the bowel thoroughly washed out before the patient comes to the theatre. Before commencing the operation, and after the patient is under the anæsthetic, the bowel is again washed out with soap and water and some alkaline antiseptic solution, such as lysol (1 drachm to the pint) or monsol. The patient is placed in the lithotomy position and the piles are seized in artery forceps; each pile is treated in turn, being drawn down and, with a blunt pair of scissors, separated from the muscular wall at the mucocutaneous junction. The scissors should open up the submucous space, and the pile is then gently stripped from its bed and the ligature of No. 2 catgut is passed round the neck high up and tied very tightly. Each end of the ligature is next threaded upon a curved needle and brought through the divided edge of the skin opposite the base of the pile so as to form a mattress suture. When the two ends are lightly tied the skin edge and the base of the pile will be approximated, and the total area of wound which has to heal by granulations will be much diminished. The pile is then cut away, taking care not to go too near to the ligature lest the stumps should retract, precipitating hæmorrhage. This procedure is repeated with each pile in turn. Any spouting vessels, not included in the ligature, are either twisted or tied off with fine catgut. Ligature of the piles often produces a diaphragm; this should be stretched or torn back with the two fore-fingers to make sure there is no narrowing of the lumen. Any external piles or tags are trimmed away with scissors; on no account should they be ligatured. Lastly, an ounce of sterilized vaseline is squeezed into the bowel from a collapsible tube, and a small rubber drainage-tube with a loop of silk attached to it is passed through the external sphincter and the dressings are applied. The tube is removed next day and the bowels are relieved on the third day by means of an enema. The tube may be dispensed with, but is useful to give warning of hæmorrhage.

Local anæsthetic for hæmorrhoid operations.—The patient is placed in the lithotomy position, and with a fine needle four wheals are made at different points in the skin, about 1 in. from the anus. (Fig. 549.) About 10 c.c. of a 1 per cent. solution of novocain is used to connect up the wheals subcutaneously. Next, a needle 10 cm. in length is used to inject the ischio-rectal fossæ, and an area in front and behind the rectum, four points in all. The left index finger is introduced into the rectum during the act of injecting the novocain, and hooked round the sphincter, in order to guide the needle-point to the right depth outside the bowel and to ensure that the point of the needle does not puncture the rectum. (Fig. 550.) Thus a circular area around the rectum is injected. About 30 to 40 c.c. of novocain solution is used altogether. The actual tissue to be removed is not injected, and is thus not distorted by the solution, which is entirely external to the operation field. About ten minutes will elapse before the rectum is rendered anæsthetic ; anæsthesia lasts, as a rule, from thirty to sixty minutes. One of the most important details is to inject thoroughly the external sphincter muscle, as unless this is properly anæsthetized the patient will experience a good deal of pain and the surgeon will not obtain good access to the piles. A small spinal anæsthetic is the best form of anæsthesia for most cases and can be combined with avertin anæsthesia in nervous patients.

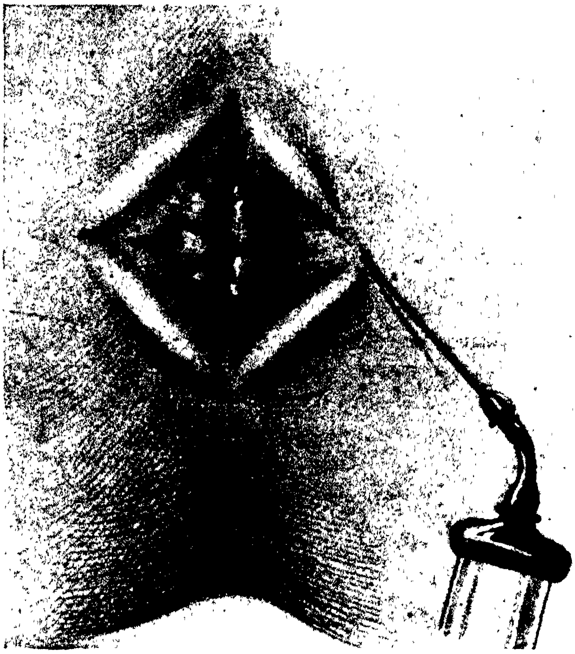

Fig. 549.—Removal of piles under local anæsthetic, showing four cutaneous wheals connected by subcutaneous injection.

Injection treatment of piles.—This should not be looked upon as a substitute for operation, as the results in most cases are transitory, the piles returning in about eighteen months or two years and requiring further treatment. It is, however, a most satisfactory means of treating internal piles in selected cases.

Technique.—Two methods are commonly employed: the injection of a 5 per cent. solution of carbolic acid in almond oil into the submucous tissue just above the pile; and the injection of a strong solution of carbolic, 10 or 20 per cent. in glycerine, into the centre and base of the pile itself. The best result, in my opinion, is attained by a combination of both methods. The essential principle is the same whichever is used. The solution should not be injected into the blood vessels but into the connective tissue between them, and the success of the surgeon in performing this little operation will depend upon his ability to place the solution in the correct manner.

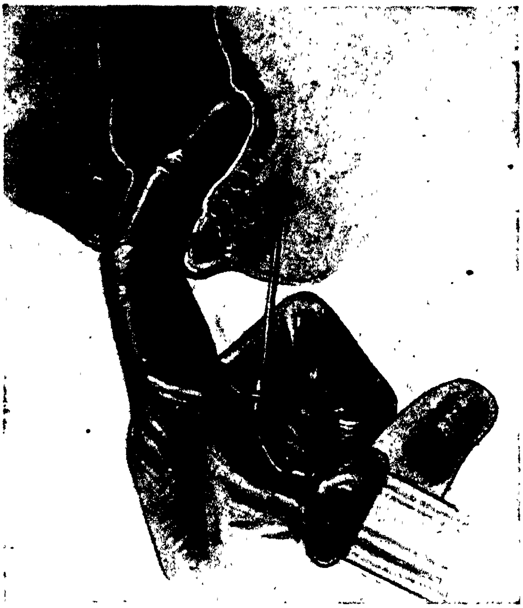

Fig. 550.—Removal of piles under local anæsthesia, showing injection of anæsthetic into tissues outside sphincter muscles, with digital guide in rectum.

The weaker solution consists of 5 per cent. carbolic in sterilized almond oil, to which 2 grains of menthol to the ounce is added; 3 c c. of this solution is placed in a syringe with a long special needle. A St. Mark's pattern tubular speculum (Fig. 551) is now passed into the rectum, with the patient in the kneeling or left lateral position, and the point of the needle is pushed through the mucous membrane just above the pile. The injection is made slowly. If the needle is in the right place, *i.e.*, just under the mucous membrane, a swelling will appear immediately, and will spread in all directions. About 3 c.c. of the solution should be injected and then the speculum should be removed. The injection should not cause any pain at the time and only a very mild discomfort for a few hours afterwards, which will not prevent the patient getting about as usual ; but he should be warned not to walk much or do anything strenuous for twenty-four hours. One pile should be treated at a time and there should be a week's interval between injections, which should be continued until all symptoms have disappeared.

When the other method is used, with the strong solution, the needle is plunged deeply into the middle of the pile, and 3–6 min. only of the solution is injected. Before actually making the injection the point of the needle should be slightly drawn back so that it lies in the cellular tissue and not in one of the veins, and on making the injection the pile should be seen to undergo slight tension, but there should be no considerable swelling.

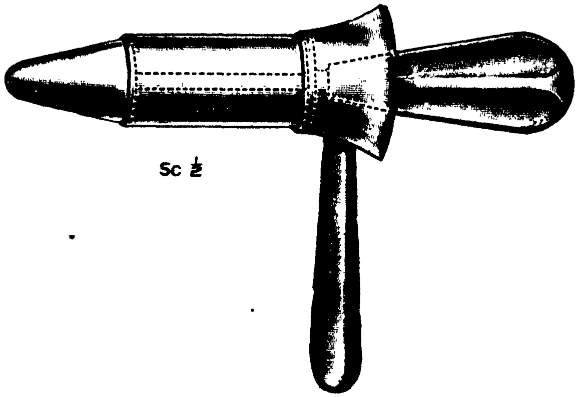

Fig. 551.—Short rectal speculum, St. Mark's pattern.

The effect of the injections is to cause a non-septic inflammation of the pile which, in the course of a week or ten days, obliterates the enlarged blood-vessels. On no account should solutions other than carbolic be used, as they are not sufficiently antiseptic, and septic inflammation may result. Many abscesses have been caused by the injection of urea-quinine solutions. Injections must not be made into external piles, or into internal piles which are prolapsed outside the sphincter muscle.

FISSURE

A fissure, if at all large, or if it has thickened edges, is best excised, so as to leave healthy tissue to heal. The first finger of the left hand should be inserted into the rectum and the parts drawn down, and then with a knife the fissure may be dissected out (Fig. 552), together with any fibrous thickening, care being taken not to cut the external sphincter ; at the most, only a few fibres of the muscle should be divided. The incision should be continued well out on the skin so as to provide thoroughly free drainage, and for the same reason the skin edges are cut away. The wound should be very lightly packed with wool (Fig. 553) and an external dressing applied. It should be lightly re-packed twice a day, and may be expected to heal in a fortnight or three weeks. The wool placed in the wound at the operation should be allowed to come away by itself, and should not be pulled out.

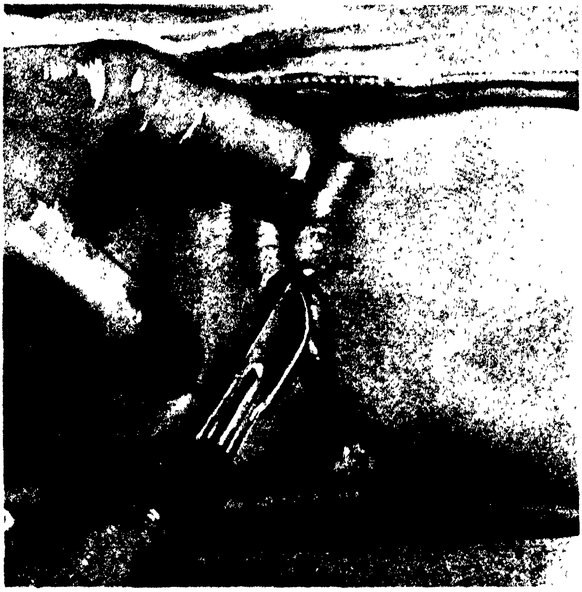

Fig 552.—Operation for fissure. The fissure is being divided with a knife. The external sphincter is not cut, but free drainage is obtained for the whole area

FISTULA IN ANO

It is common in old-standing fistulæ to find multiple external openings, which may be scattered far and wide. These nearly always prove to be posterior horseshoe fistulæ with their internal openings in the middle line behind, for they are six times as common as the anterior horseshoe variety.

It should be remembered that, although tracks may run up parallel with the side of the bowel, the actual internal opening is never above the internal sphincter, but usually between the two muscles, and not infrequently below the external sphincter muscle.

Treatment.—There is only one form of treatment : freely to lay open all the tracks and by careful dressing to get them to heal up from the bottom. This must be done in such a manner that there is no danger of causing permanent damage to the external sphincter muscle, which would inevitably result in loss of perfect control over the anal opening.' When the fistula is very extensive, with numerous side tracks, the operation should be performed in stages, as complete division of all the tracks at one sitting will cause too much displacement and subsequent deformity.

The external openings should first be connected together by laying open the tracks with a knife guided by a curved steel director passed along the track or tracks. It will generally be found that there is one track at the back which passes forwards to open in the anal canal. This track should be left until all the others have been freely laid open. After all tracks have been divided except that going into the bowel, the fibrous tissue surrounding the tracks should be dissected carefully away so as to leave only healthy tissue. If this is not possible without damage to the rectal wall, it should not be done, but the track should merely be laid open as freely as possible. All overlying skin edges should be cut away and any bleeding stopped, preferably by twisting the vessels on forceps. It is better to avoid ligatures as far as possible.

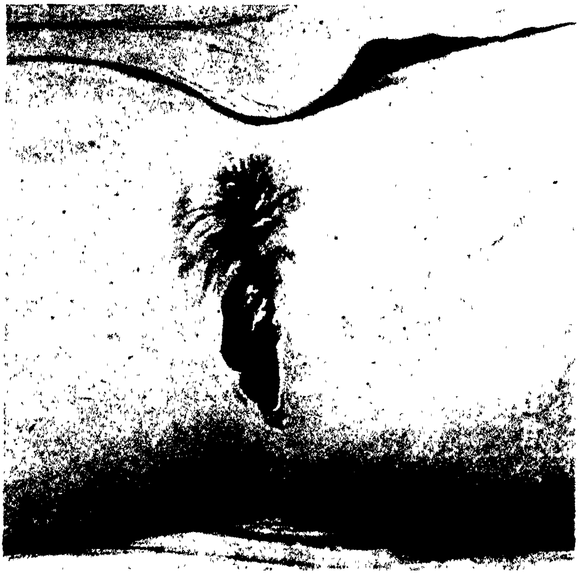

Fig. 553.—Operation for fissure. The wound is lightly packed with wool.

The track leading into the bowel is best left alone and divided a fortnight later, after partial healing of the outside wound. In this way damage from retraction of the cut ends of the sphincter can be avoided and no extra time in healing is entailed. When the track leading to the rectum does not pass deep to the sphincter muscle, or only involves a few fibres, it may be cut through at the primary operation, but if this will involve any serious division of the muscle

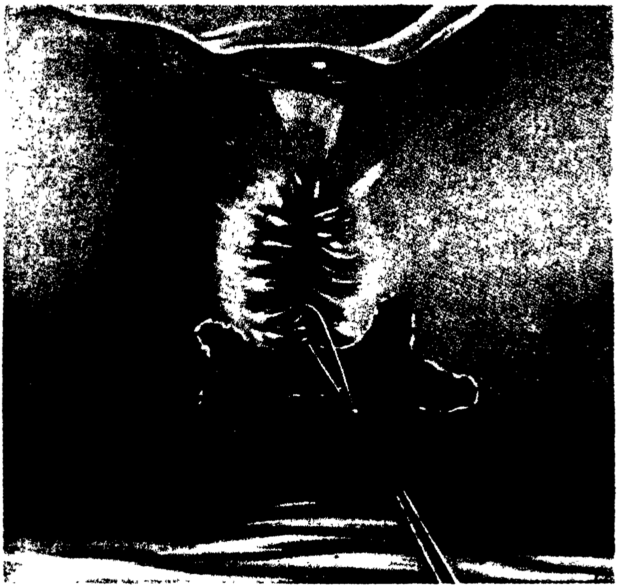

Fig. 554.—Operation for fistula. The external tracks have been cut away and a ligature of silk placed round the external sphincter, but the muscle has not been divided.

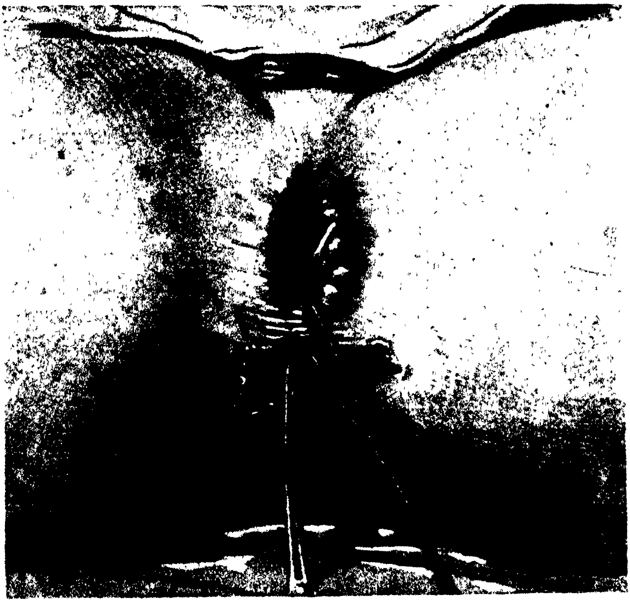

Fig. 555.—Operation for fistula, second stage, showing a probe director passed along the internal opening guided by the silk ligature preparatory to division of the muscle.

fibres, a silk ligature should be passed through the track and tied loosely in a loop so as to act as a guide to the division of the tissues overlying the track at a later date. (Figs. 554, 555.) The best time to divide the deep internal track is a fortnight after the primary operation, and it can usually be performed quite readily after injection of some local anæsthetic into the tissues which have to be divided. The wound, unless very deep, is not packed, but simply left open and a flat compress applied over it. Dressings are changed twice daily after the patient has sat for 15 minutes in a warm bath. Healing should be rapid and painless. During the later stages of healing oily dressings should be used, such as gauze dipped in castor oil or liquid paraffin.

Healing can often be accelerated, in suitable cases, by dissecting away all the fibrous tracks and leaving only healthy tissue. The wound is left wide open and allowed to granulate from the bottom. It must be carefully watched to ensure absence of bridging. In all fistula cases the surgeon should personally supervise the dressings. Primary suture of fistulæ has often been attempted, but has not proved successful.

In horseshoe fistulæ with multiple openings it is common to find tracks running up parallel with the bowel, and in these cases there is often considerable delay in the healing of the wound. These tracks are best treated by the insertion of a rubber tube, which admits free drainage and allows the site to be irrigated through the tube ; it is often necessary to scrape such tracks and to improve upon the drainage should the exterior of the wound tend to close in too quickly.

PROLAPSE OF THE RECTUM (PROCIDENTIA) IN ADULTS

This condition is a state of protrusion involving all the coats of the bowel ; the prolapsed portion of bowel may vary in length from 2 to 6 in. In cases of long standing the anus is patulous, and the sphincter muscle very much overstretched or completely inadequate. (Fig. 556.)

I have devised an operation* for prolapse of the first and second degrees which has proved very successful. The rectum is thoroughly cleansed with either soap or lysol solution (1 drachm to the pint), followed by the application of 75 per cent. spirit and picric acid ; the skin surrounding the anus and buttocks is prepared in a similar way. A piece of gauze is then packed into the rectum to prevent any leak of fæcal matter during the operation. A transverse incision 2½ in. in length is made midway between the tip of the coccyx and the posterior margin of the anus ; the attachment of the external sphincter to the coccyx is divided, and the postrectal space in the hollow of the sacrum freely opened up. With the gloved finger this area is stripped as high up on the sacrum as can be reached, and the space thus laid open is lightly packed with vaseline gauze to prevent primary union. It is important to avoid too tight packing. The wound is sewn over the packing, but one stitch should pass through the edge of the gauze. At the end of a week, the wound is opened under an anæsthetic, and all packing removed. It is irrigated, and re-packed as before. It should not be entirely removed till 14 days after operation. The patient should be kept lying in bed for at least four weeks, and the bowels confined until the seventh day after operation.

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* "Diseases of the Rectum and Colon." Baillière Tindall and Cox.

An operation for dealing with prolapse in women was described by Dr. J. McCann.* It consists in exposing the space in front of the rectum by an incision in the posterior vaginal wall and carefully suturing together the anterior attachments of the two levator muscles and the neighbouring pelvic fascia.

Whatever operation is performed, if the anus is completely patulous it will be necessary to do a plastic repair on the sphincters. It is usually best to postpone this until a fortnight after the operation on the prolapse; but if desired, it can be performed at the same time. The sphincter muscle is exposed by a curved incision in the skin about $\frac{3}{4}$ in. from the anal margin. This excision should expose about half the muscle, either anteriorly or posteriorly. The muscle must then be shortened to the required extent to enable the opening to close efficiently.

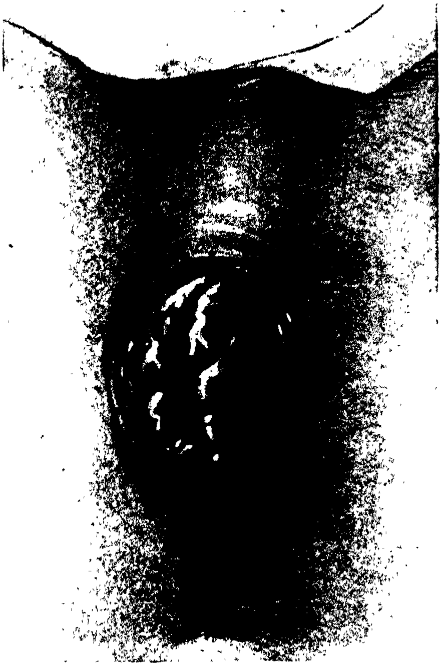

Fig. 556.—Complete prolapse of rectum.

Amputation of prolapse.—In very bad cases of prolapse where part of the colon comes down in addition to the rectum, i.e. where the prolapsed portion is 6 in. or more in length, neither of these operations is capable of curing the condition, since they cannot control the whole of the displaced bowel. In these circumstances the best operation is complete amputation of the prolapse, a rather formidable procedure, as it involves opening the peritoneal cavity.

Technique.—The patient is placed in the lithotomy position and tipped slightly head down. The prolapse is drawn down as far as it will come and the mucous membrane is divided transversely, starting anteriorly, until the peritoneum is exposed. This is opened and care taken to see that any small gut is replaced in the abdomen. The peritoneum is divided back to the mesentery and then the peritoneal cavity is carefully closed by stitching the divided edge of the peritoneum to the wall of the colon all the way round. When this is completed the prolapse is amputated from in front backwards, proceeding in sections, the two edges of mucous membrane being carefully approximated with sutures before the next part of the bowel is divided. Lastly, the vessels in the mesentery at the back are clamped and tied, and this portion of the rectal mucosa is sutured.

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* *Proc. Roy. Soc. Med.*, March, 1928, xxi, 891.

Bleeding is rather free, and a considerable number of vessels have to be ligated. The suturing of the mucous membrane is best done with independent mattress-sutures of No. 1 chromic catgut. When the operation is completed, the sutured stump of bowel is replaced, and a large bore tube is inserted well above the line of suture.

Operations such as colopexy, for fixing the colon from the abdomen, have not proved very successful and are now seldom performed.

PRURITUS ANI

In a few cases of this condition the irritation is so severe and intractable that surgical interference is called for. Such cases are usually of long standing and the patient is unable to get any relief from local applications. They used to be treated by excision or cauterization of the involved skin areas, but the resulting contraction often caused the final state to be worse rather than better.

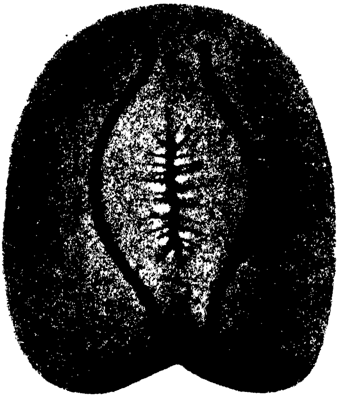


Fig. 557.—Ball's operation for pruritus ani : skin incision.

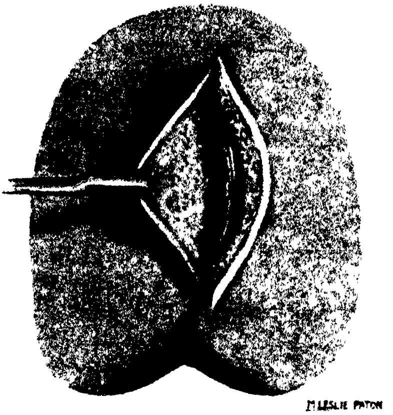


Fig. 558.—Ball's operation.: one flap dissected up.

In these days such cases are treated by the operation associated with the name of the late Sir Charles Ball, of Dublin, and the results are admirable, providing the operation, which is rather difficult, is properly performed.

Operation.—After thorough preparation, the patient is placed in the lithotomy position and two curved incisions are made in the skin (Fig. 557). The flaps of skin are then dissected free towards the anus (Fig. 558.) Care must be taken not to make the flaps too thin, nor, on the other hand, to include any part of the external sphincter. In order to dissect the flap on the operator's left side it is necessary for the surgeon to use the scalpel or scissors with his left hand, as it cannot be properly done with the right hand with the patient in the lithotomy posture. With the patient in the left lateral position it can·readily be managed. The whole of the area of skin enclosed within the incision is dissected loose, up to and a little above the level of the external sphincter. When this has been completed, the skin will be attached only to the mucous membrane of the rectum and to the pedicles in front and behind. These pedicles should also be undercut. Bleeding is stopped by picking up the vessels and twisting them, ligatures being avoided if possible.

The object of the operation is to divide all the nerves passing to the affected skin and, unless the dissection is carefully carried out and taken far enough up inside the muscular structure, many of the nerves which pass down in the submucous layers will be missed.

When the dissection is completed the skin-flaps are sewn back into position and thin rubber drains are placed under the flaps. A firm dressing which holds the flaps well down should now be applied, to prevent the formation of a hæmatoma. There should be no fear of gangrene of the flaps providing a hæmatoma is not allowed to form. The drains may be removed in two days and the stitches in eight. The patient's bowels should be moved by an enema on the fifth day. Dressings should, after the first day, be changed twice daily. The wounds should be healed in 14 days and sensation will return to the skin which has been included in the flaps in about 6 weeks.

There are several modifications of this operation, but they are not so satisfactory as the method originally described by Ball. The operation is much more difficult than it seems from the description, owing to the rather complicated shape of the skin-flaps.

The results are very satisfactory and the pruritus seldom recurs.

IMPERFORATE ANUS

There are many different varieties of this condition. It is usually detected at birth, and if there is no opening to allow the fæces to escape something must be done at once. It is as well to remember that in girls the end of the bowel often opens into the vaginal passage, and in such cases no immediate operation is required ; slight dilation of the existing passage will be all that is necessary.

In boys, or in girls when no opening exists, an operation is necessary. An incision should be made from the base of the scrotum to the tip of the coccyx in the midline of the perineum. The rectal pouch should be felt for in the hollow of the sacrum with a finger while the nurse presses upon the baby's abdomen to make it bulge downwards. When found it should, if possible, be loosened and brought down to the skin before being incised. If this is not possible it should be incised *in situ*, and if possible the skin and mucous membrane should be attached to each other by a few stitches. Owing to the size and age of the patient the procedure will have to be as simple as possible, all that is really required being to provide an opening for evacuation. Proper repair of the parts should not be attempted, but left until the child is older. Care must be taken not to deepen the incision in front, or the bladder may be injured. When it is not possible to find the rectum at all, a colostomy is the only possibility.

Subsequent restoration of the parts.—The impossibility of performing any form of plastic operation upon an infant's perineum makes it advisable to postpone any attempt to remedy the condition until the child is about eight years of age, when an operation may be performed to remedy the defect as far as possible. The best results will be obtained in girls in whom the rectum opens in the posterior vaginal wall. An incision is made in the central line of the perineum and the opening of the rectum is dissected out from the posterior vaginal wall and, after being freed, is transplanted to its proper position ; the parts are then restored. As a rule there is no trace of any sphincter muscle, but very fair control is obtained and the child becomes almost normal.

In boys the operation is more difficult, but very good results can be obtained by a carefully planned plastic operation performed between the ages of 8 and 12. In all cases the mucosa should be made to heal to the skin, so as to prevent contraction of the opening, and the constant necessity for the use of dilators.

ISCHIO-RECTAL ABSCESS

The most important consideration is to open such abscesses at the first possible opportunity. Too often they are treated expectantly by hot fomentations until they have already burst, either into the rectum or through the skin. In such circumstances a fistula is almost certain to result, whereas if the abscess is well opened directly it shows itself this complication can frequently be avoided.

Directly an abscess is detected, an opening should be made into it. The best way of doing this is to inject 2 per cent. novocain, by a fine needle, into an area of the skin about the size of a shilling at the point chosen, and then to plunge a knife through this area into the abscess. When the abscess has already been partly evacuated, the edges of the skin should be cut away so as to leave a large drainage aperture. No packing or tube should be inserted, but the abscess must be allowed to drain, and for the first few days the opening should be kept patent with dressing forceps, and the patient should be made to give himself a good soak twice daily in a hot bath and to apply wet dressings between times.

The size of the opening should depend upon the size of the abscess ; roughly it should represent one side of the abscess cavity, to ensure really free drainage. The results by this method of treating ischio-rectal abscess are much more satisfactory than where tubes or packing are used, and there is far less pain.

INCONTINENT ANUS

It sometimes happens that, as the result of an operation or injury, the sphincter muscle is damaged and is no longer able adequately to close the anal orifice. Needless to say, such a condition is very distressing to the patient, who will be anxious to have the muscle restored by operation.

Operations for the plastic repair of the sphincter muscles are difficult and the technique will vary according to the circumstances. For the exact details of such operations the reader is advised to consult one of the standard textbooks on diseases of the rectum ; all that can be said here is to give some of the main principles for obtaining success.

As the success of the operation will depend very largely upon obtaining primary union in the wound—a difficult matter in the neighbourhood of the anus—the greatest care is necessary to ensure that the rectum is empty and clean when preparing the patient for operation, and to keeping the parts clean after operation while healing is in progress.

All dense fibrous scar tissue must be cut away so as to leave only healthy tissue, and the ends of the divided muscle, when found, must be well freed, so as to avoid tension on the stitches. The ends of the muscle should be grafted into each other and secured in place with fine catgut sutures, and the skin wound should be carefully closed after stopping all bleeding points.

Incontinent anus due to stretching, as, for instance, in severe and long-standing cases of rectal prolapse, requires special treatment. It is useless to expect to obtain a cure of the prolapse if the patient has a patulous anus, and the muscle must be shortened or a recurrence is inevitable. In some cases the muscle will shorten and recover its normal tone after the prolapse is operated on, but this cannot be expected when the anus is badly patulous. The muscle should be exposed by a semicircular skin incision, preferably in front of the anus, and either shortened by plication, or part of it resected and the ends joined again.

CHAPTER XXVI

RADIUM IN SURGERY

By GEOFFREY KEYNES

RADIUM or its emanations, since the beginning of its use as a therapeutic weapon, has held a somewhat anomalous relationship to surgery. Its properties being at first but imperfectly understood, its mysteries were left in the hands of physicists and radiologists who administered them with little reference to its surgical possibilities. Since 1920, with the growth of " team work " in all departments of medicine and surgery, the position has changed, until at the present time radium occupies so definite a place in surgery that some account of its use must obviously be included in any comprehensive account of surgical technique. At the same time its use must not be regarded as fully standardized, or made safe and easy by the introduction of rules-of-thumb, so that any surgical practitioner can employ it without particular thought or training. The very opposite is true, for many of the applications of radium are still in an experimental stage, and emphasis must be laid on the fact that it can be both inefficient and dangerous if used without proper training and knowledge. This training and knowledge must be surgical as well as radiological, if radium is to be used to full advantage. Recognition of this fact is reflected in the policy of the National Radium Commission, which has made the national radium available at a few large centres where all the necessary knowledge, physical, radiological, surgical and pathological, is available. The indiscriminate use of radium in unsuitable ways and for unsuitable cases is thus avoided, and further knowledge of its proper use can be accumulated on a sound basis. If this position be accepted, obviously it would be difficult to convey in a few pages of a surgical text-book any adequate account of how radium should be used. For the theory of radium-therapy reference must be made to special works on the subject or to Stanford Cade's book " Malignant Disease and its Treatment by Radium." For any account of the results obtained in different regions of the body up to the present time, the original papers must be read. In this chapter the particular application of radium in relation to surgery will be chiefly considered, and only brief reference will be made to the more general radiological aspects of the problem.

Effect of emanations.—The therapeutic activity of radium is due to the disintegration of the radium atom, a series of different radiations, emanations and substances being produced at various stages of the process. Radium itself disintegrates at a relatively slow rate, its " life " extending to some thousands of years. One of the first products of its disintegration, the gas " radon " or " radium emanation," has, however, a short " life " of only a few days, and the energy liberated in the disintegration of this radon is that actually used to obtain the therapeutic effects of radium. Three forms of radiation, α, β, and γ, are liberated in the process, but of these only the third is used for therapeutic purposes. The α-rays are positively-charged atoms of helium and, having a very feeble power of penetration, are of no practical importance. The β-rays are negative electrons with a power of penetration greater than that of α-rays, but much less than that of γ-rays. They are absorbed by 1 cm. of body tissues, but have a caustic effect on all tissues on which they impinge, so that it is usually desirable to remove them. This is achieved by interposing a metal screen (*vide infra*). The γ-rays (unlike the α- and β-rays, which are really solid particles) are short-wave vibrations in the ether, moving with the velocity of light. They have a very high power of penetration, 160 times that of β-rays, and it is on their peculiar therapeutic properties that the use of radium depends. All tissues are affected by the γ-rays, but to a very varying degree. Highly organized cells, such as leucocytes or muscle fibres, are affected more than those of connective tissue, and the skin is easily " burnt," but, on the whole, normal tissues are very much less sensitive to γ-rays than the cells of malignant neoplasms. The action of the rays is therefore said to be " selective," and the correct amount of irradiation should have a lethal effect on malignant cells while leaving the normal tissues practically unaffected.

The effect on malignant cells is seen first in the cessation of mitoses and cell division. The cells then slowly disintegrate and are absorbed, leaving the connective tissue stroma in which they were growing. Even malignant cells, however, are not all equally affected by the γ-rays, and there is a wide range of sensitivity. Thus, the epithelial growths in the posterior part of the tongue or at the anal margin are highly " radio-sensitive," while those in the anterior part of the tongue or in the rectum itself, are relatively insensitive. The successful application of radium in surgery therefore requires a wide knowledge of the biological reactions of the different tissues, as well as the principles of dosage. Incorrect dosage may result in widespread necrosis of tissue if the dose be too large, or in actual stimulation of a malignant growth if it be too small, so that the possible dangers of radium treatment are very great. The term " dose " moreover includes two distinct factors : (1) the amount of radium and (2) the time of exposure, and each of these must be known separately, so that the estimation of a dose in the form of " milligramme-hours," the product of the two factors, gives in reality very little information. It may be said that the surgical use of small quantities of radium for long periods, up to seven days or more, has given better therapeutic results than the use of large quantities for short periods, and this principle is of very general application. It must be admitted, however, that the estimation of dosage has been empirical rather than theoretical, and that experience is a better guide than any calculation according to rule.

Although the successful employment of radium in surgery requires a general knowledge of the various ways in which radium may be applied, a detailed consideration of its external application has no place in a text-book of surgical technique. Indeed, distance irradiation with the so-called " bomb " containing 4 grammes of radium, or more, is a separate problem which need not concern the surgeon. He must, however, be familiar with the methods of using smaller quantities of radium externally on wax moulds made of " Columbia paste," or on pads of " Sorbo " rubber. A primary malignant lesion may be treated by more strictly surgical measures, but the glandular areas may require external treatment ; or, again, recurrent growths after operation, such as secondary nodules on the edge of the sternum after a radical operation for carcinoma of the breast, may not be amenable to any treatment other than external.

Survey of Technique.—Surgical technique is mainly concerned with the implantation of radium in the tissues, that is to say, it is the method of " interstitial irradiation " which chiefly demands attention. For this purpose the radium must be disposed in containers suitable for insertion in a variety of situations. For most purposes these containers or " needles " are made on a standardized plan. They consist of hollow iridio-platinum tubes inside which tiny glass cells are packed containing the radium sulphate. (Fig. 559.) In this way 1 mg. of radium element is distributed over a standard length of 1·6 cm. (i.e. 1 cm. contains approximately 0·6 mg. of radium), and whatever the length of the needle may be, this uniform linear intensity is to be observed, since accuracy of dosage is more easily achieved with a constant unit of intensity. The screening of the radium is effected by the platinum tube, and it is known that practically the whole of the β-rays is absorbed by 0·8 mm. of platinum. This is probably the best standard of screening. A thickness of 0·5 or 0·6 mm. has been much used, but is appreciably less efficient as a screen. The additional strength of 0·8 mm. of platinum is also an advantage in the longer needles, which are then less likely to bend. This thicker screen is better because it does make possible a larger therapeutic dose without damage to the normal tissues, although the additional amount of β-radiation removed by it is very small indeed. As shown in the diagram, the ends of the needles must necessarily be solid and therefore " dumb," except for the small amount of secondary rays which they will emit. At one end the needle has a round, conical, or trochar-shaped point ; at the other an eye through which some form of thread may be passed. The shape of the point is made according to the taste

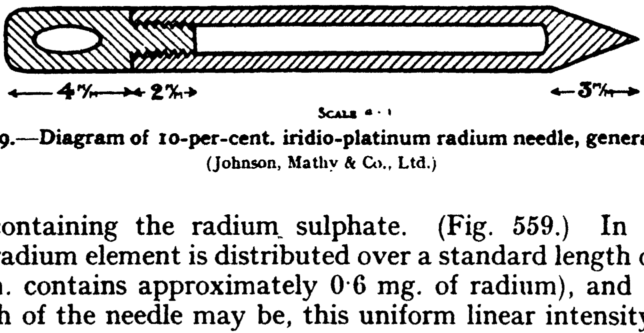


Fig. 559.—Diagram of 10-per-cent. iridio-platinum radium needle, general type.
(Johnson, Mathy & Co., Ltd.)

of the operator. Some have supposed that a trochar point is dangerous, since it is more likely than a conical point to pierce vessels or nerves ; this danger, however, is remote if the needles are used with proper care, and the trochar point makes them easier to introduce into tissues that are at all tough.

The needles most commonly used contain 0·5, 1, 2, or 3 mg. of radium, and their active lengths are therefore 0·8, 1·6, 3·2, and 4·8 cm. Other lengths have been made for special purposes ; it is important to realize that efficient treatment for any particular condition can only be given with the appropriate apparatus, and that it is unsound to vary the technique according to what apparatus " happens " to be available. These platinum needles, though apparently solid and strong, are in reality somewhat fragile, since they are hollow and therefore easily bent or cracked. Also, the end containing the eye is easily crushed if grasped in an ordinary pair of artery forceps. It is further important that any operator who is frequently using radium should avoid touching the needles, lest his fingers, in the course of time, develop radium dermatitis. Rubber gloves constitute no protection whatever. For

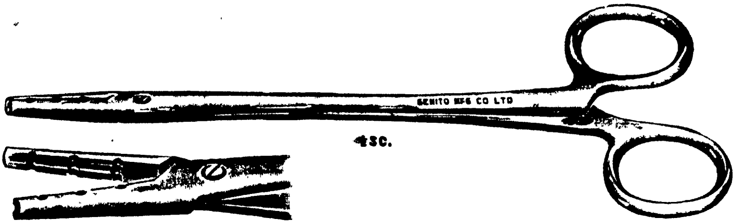


Fig 560.—Radium-needle holder of Finzi's pattern ; straight.

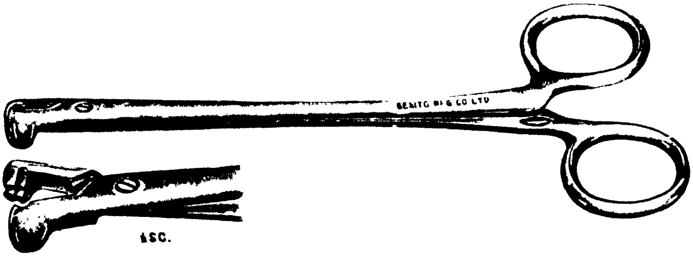


Fig. 561.—Radium-needle holder, Finzi's pattern ; angled.

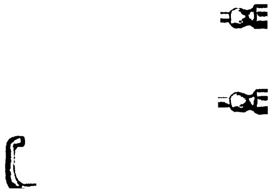


Fig. 562.—Radium-needle " pushers."

several reasons, therefore, it is absolutely necessary to use some form of radium needle introducer. A number of these are on the market, and all utilize the principle of a groove in the jaws along which the needle may lie undamaged. One of the simpler forms, designed by Finzi, is illustrated. It is necessary to have two varieties, a straight one holding the needle in line with the introducer (Fig. 560), and another holding it at an angle. (Fig. 561.) It is also useful to have radium-needle " pushers " (Fig. 562), straight and angled, with sockets at the ends fitting the ends of the needles, which can be pushed home by their aid. Some operators have thought it necessary to introduce the needles by the trochar-and-cannula principle, the needles being pushed by a stile along the cannula after it has been introduced into the tissues. This instrument inflicts some additional damage on the tissues, and is usually unnecessary. A compromise may, however, be advantageous, to introduce a short needle into a somewhat inaccessible place. Thus, a neat instrument has been designed by Ogier Ward (Fig. 563) for putting needles into the wall of the bladder or around the prostate gland by the suprapubic route. The needle is held in the grooved jaws and is pushed into the tissues by a stile, though no cannula is used. A somewhat similar instrument for more general use has been designed by Roy Ward. (Fig. 564.)

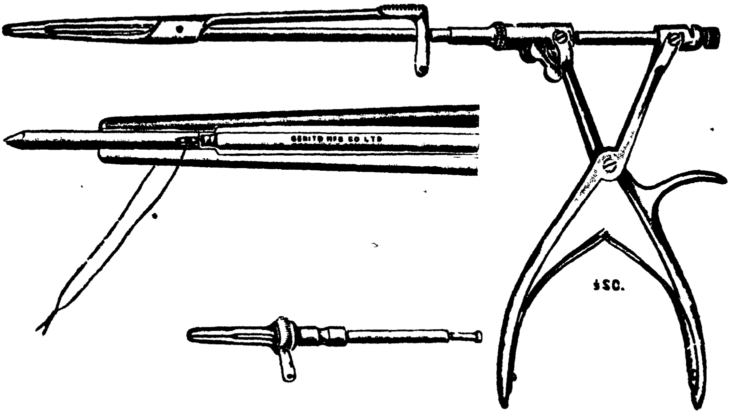


Fig. 563.—Radium-needle holder with stile, Ogier Ward's pattern.

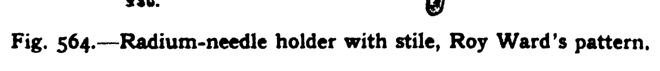


Fig. 564.—Radium-needle holder with stile, Roy Ward's pattern.

Fixation of needles.—The supply of radium has greatly increased in recent years, and its cost has been reduced, but it is still expensive enough to make its conservation extremely important. Needles are usually left in position in the tissues for seven days or more and once they are in the correct position any movement is undesirable. When needles have been introduced through the skin overlying some relatively immobile part of the body, such as the chest wall, or even into a situation such as the axilla, it is usually not necessary to fix them separately. Loss of any one needle may be prevented by knotting together the threads of several needles in groups of about four. A needle can then become completely displaced out of the body without becoming detached, unless the thread holding it should break. This breakage may be avoided by choosing some substance of considerable strength ; strong thread will also facilitate removal, since the operator can then pull the needles out without using any instrument and so avoid damaging them. Various kinds of thread have been used, the most generally serviceable being thick silkworm-gut, which must, however, be kept moist for 24 hours before use, so that it may not crack near the eye of the needle when it is held in the introducing forceps. Silkworm-gut, being non-absorbent, is less likely to provoke sepsis at the skin surface than an absorbent material. The two ends of the thread should be knotted about 1 cm. from the end of the needle. It will then exert a straight pull on the needle during removal, and the needle will not become caught in the subcutaneous layer. Occasionally, however, needles do become caught, and then the ends may often be guided to the surface by an aneurysm needle, or, better, a Moynihan's ligature-carrier with a groove cut in the end. This technique will serve for almost any situation where the needles have been introduced through the skin. When copper wire is used, the needles are easier to remove than with silkworm-gut. The wire is objectionable, however, in that it causes some necrosis of the skin at the point of emergence and, therefore, more sepsis.

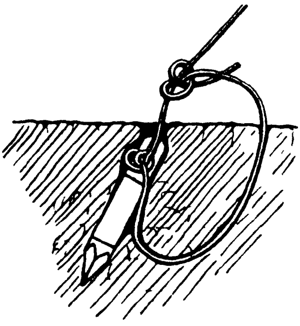


Fig. 565.—Short radium needle introduced into the tongue, showing method of fixing with silk loop (after Stanford Cade).

A different technique must be employed when needles are inserted in the tongue or buccal cavity, where the parts are mobile, and where a stiff material, such as silkworm-gut, would be irksome to the patient. Here it is necessary to use No. 4 black silk, which is very strong and somewhat antiseptic by virtue of the iron in the dye with which it is impregnated. The ends of the silk threads may be given stiff, sharp points by singeing them in the flame of a spirit lamp, and then threading becomes easy. A knot must be made at the end of the radium needle, and one end of the thread must be threaded through the eye of a very small fistula needle. When the radium needle has been introduced into the tissues, the fistula needle is taken in a needle-holder and passed through the mucous membrane close to the radium needle. The two ends of the thread are then tied, and thus the radium needle is held in position by a loop of thread through the neighbouring mucous membrane. (Fig. 565.) One end of the thread is cut short. All the long ends are then twisted together and the whole bundle is fixed on the outside of the cheek by adhesive rubber strapping. The mucous membrane of the corner of the mouth may be protected from excoriation by the moist bundle of threads by passing the bundle through a piece of soft rubber tubing. Even then, one or more needles may become displaced after a few days. In this case it may be necessary to re-insert the needles and there is, indeed, a certain advantage in " re-needling," since a fresh distribution of radium is obtained for the remaining period of irradiation. An alternative method of fixing needles has been used on the continent, and in this country by Douglas Harmer. The needles are inserted in pairs and pass obliquely into the tissues, one from before backwards and the other in the opposite direction. The threads attached to each are then tied together, so that the pull of each needle tends to fix its fellow in position. For general use the first method described seems to be the best, as every needle can be inserted with full regard only to its relation to the lesion to be treated.

Surgery of access.—The description of the general technique of interstitial irradiation so far given has assumed that the needles are introduced through the surface, either directly, as in the mouth or the scalp, or else through small punctures made with the point of a narrow-bladed scalpel or pointed tenotomy knife. This method of introduction is of very wide application, and is the method of choice for all lesions on or near the surface. Thus, it can be used for rodent ulcer, carcinomas of the skin, tongue and buccal cavity, breast, cervix uteri or anus. It can even be used for irradiating the prostate gland, the needles being introduced through the skin of the perineum with the help of a guiding finger in the rectum. For more deep-seated lesions it is clear that the introduction of the radium must be preceded by a surgical operation for the exposure of the part affected. Thus the treatment of a neoplasm of the lung necessitates a preliminary thoracotomy ; a carcinoma of the rectum must be exposed by a posterior dissection and removal of the coccyx, or of the coccyx and part of the sacrum ; an intrinsic carcinoma of the larynx demands fenestration of the thyroid cartilage ; the irradiation of glands in the axilla or neck, especially in stout patients, may occasionally require a skin incision for accurate implantation of needles. Instances might be multiplied where radium treatment calls for "surgery of access," but full description of such operations would to a large extent duplicate information already given in other parts of the present work and is, therefore, outside the scope of this section.

Radon.—The foregoing account of interstitial irradiation refers to the use of needles containing radium sulphate. It is necessary also to describe the use of " radon gas " or " radium emanation," as this is of service when radium itself cannot be obtained. As explained above, most of the energy give out by radium is really produced during the stage of disintegration of radon. With radium in a closed container a state of equilibrium is reached, in which the disintegration of radon is balanced by the formation of more gas from the radium, so that a constant amount of energy is given out. If radon is isolated, its " life " is short, and its output of energy falls to half the original amount in the course of 3.85 days. It follows, therefore, that the intensity of the irradiation produced by radon is variable, falling off steadily from the moment the gas is isolated, until, at the end of seven days, its value is almost nil. This is a theoretical, and probably a practical, objection to its use, since it is prefereable to expose malignant cells to irradiation of constant intensity if the full effect is to be obtained. The results achieved with radon appear to have been inferior to those given by radium. Nevertheless, radon has been extensively used and it has a definite place in radiotherapy. By means of the appropriate apparatus the radon is collected from a solution of radium bromide, and is put into fine glass capillaries. These capillaries are divided into small sealed units, each containing a measurable amount of radon, and these

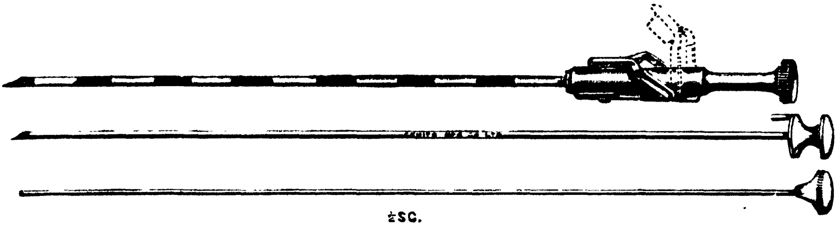


Fig. 566.—Cannula with slot and stile for introduction of radon seeds.

are introduced into tiny platinum or gold containers, usually with a thread attached at one end. This screened cell constitutes a " radon seed," and can be used in almost exactly the same way as radium needles. It must be remembered, however, that the energy given off by radon seeds is emanating from a series of points, so that it is impossible to obtain the uniform " linear intensity " given by radium needles. This is a second objection to the use of radon, though it can be to some extent overcome by accurate spacing of the seeds along a line, so that the combined effect of the seeds is almost equivalent to that of a needle. The seeds are so small that it is obviously necessary to introduce them into the tissues through a cannula, and a simple form of this instrument is illustrated in Fig. 566. Similar instruments of greater length have been devised for introducing seeds into the bronchus or œsophagus. The seeds can be introduced through these with threads attached, so that they can be withdrawn when desired. Sometimes it is better to make no attempt to do this, as when, for example, seeds have been introduced into the pituitary fossa or the pancreas ; the seeds become innocuous after about seven days, and are so small that they cause no irritation in the tissues. If the seeds are not to be removed, the threads will of course be cut off before they are placed in position. The use of seeds has been developed in certain situations, such as the breast and lung, where large numbers are needed. In order to facilitate this a " radon gun " has been devised, which has a magazine capable of holding up to 12 seeds. (Fig. 567.) As each seed is pushed into position, another one automatically takes its place in the barrel of the " gun " ; much time is thus saved in placing long lines of seeds, which can also be more accurately spaced. An objection to the frequent use of a radon gun is the danger of injury to the operator's hands by irradiation.

Technical principles.—The disposition of the radium needles or radon-seeds in the tissues is made in such a way as to conform to established surgical principles. Surgery aims at the extirpation for as great a distance as possible of a malignant neoplasm together with the surrounding tissues and the known channels of lymphatic spread with the accessible lymph-nodes in continuity. The radium should be made to irradiate the whole area which would be removed at operation, and, in certain types of neoplasm, the corresponding lymph-channels and nodes in continuity. Sometimes it is preferable to treat the primary lesion with radium, and to deal with the lymph area by operation, but even so the principle of the radium distribution is the same as far as it goes. The lengths of the needles or the numbers of the seeds are varied according to the area to be covered. Thus the mammary gland will require the longest needles, whereas for a small rodent ulcer of the face or a small carcinoma of the tongue, the shortest may suffice. In covering a given area the radium should be distributed as evenly as possible, so that in general the needles should be parallel with one another. If they are placed about 1·5 cm. apart the necessary intensity will be produced, assuming that the time of exposure is to be 168 hours (seven days). This principle is illustrated by the accompany-

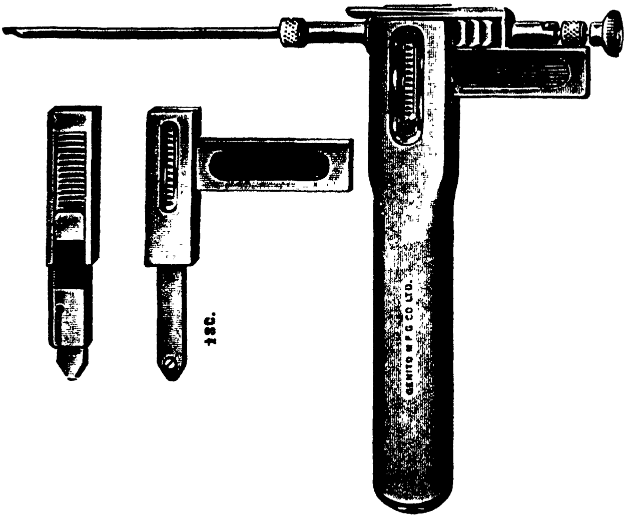
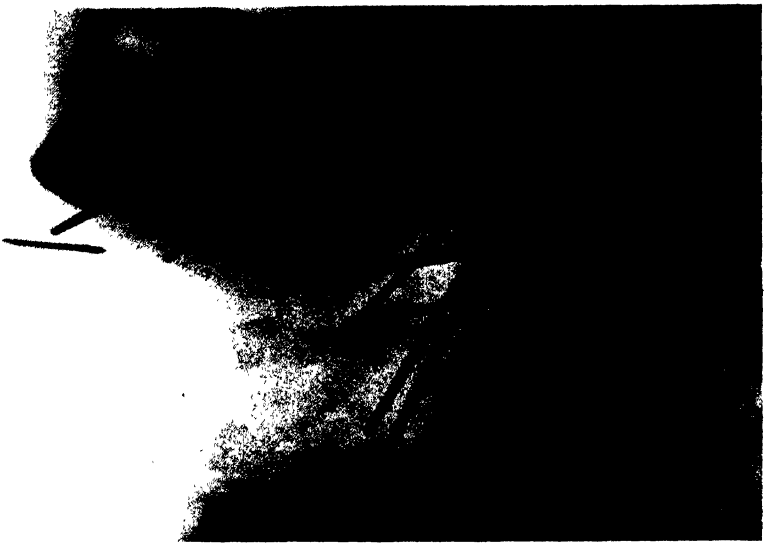
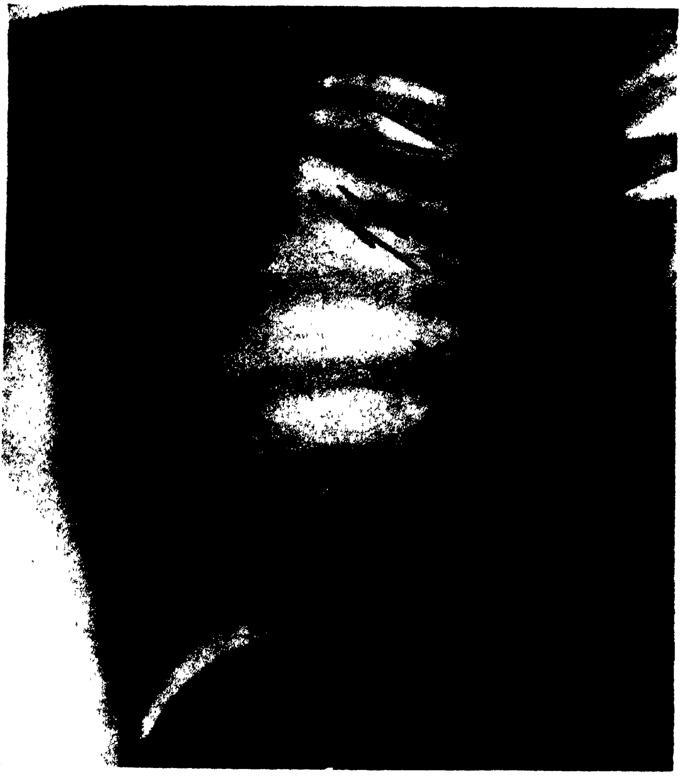


Fig. 567.—Radon-seed gun with magazine, Roy Ward's pattern.



Radiogram of radium needles in the neck, submaxillary, and submental regions.



Radiogram of radium needles under the mammary ing diagram (Fig. 568), in which three needles of an active length of 4·8 cm. are irradiating an area of 21·6 sq. cm. Usually the needles should be placed immediately deep to the lesion rather than in it, and this is advisable for four reasons : (1) the lymph-channels draining the affected area may be on its deep aspect ; (2) if needles are pushed into a growth, malignant cells may be transplanted on the inactive end of the needle into a fresh site ; (3) a needle placed in a neoplasm may have too intense an effect and sloughing may follow ; (4) the needles will be further from the skin which will, therefore, be less likely to suffer from severe burning. Where the thickness of the tissue to be irradiated is not great, a single layer of needles will suffice. Where the thickness is greater, a second layer of needles nearer the surface may be needed. It is difficult to lay down any rules for this. Experience is the best guide.

When a group of lymph-nodes or a single enlarged node is to be irradiated, the needles should be so disposed as to lie parallel with the line of lymph-flow and on all sides of the nodes. The exact disposition will be dictated by the anatomical relations of the part. Thus the interstitial irradiation of the lymph-glands of the neck and submaxillary region is carried out according to the known position of lymph-nodes, salivary glands, great vessels and nerves. (Plate V.) Another complicated problem, the irradiation of the mammary gland and all the accessible lymphatic areas, is illustrated by a radiogram. (Plate V.) This includes irradiation of the internal mammary nodes in the upper three intercostal spaces.

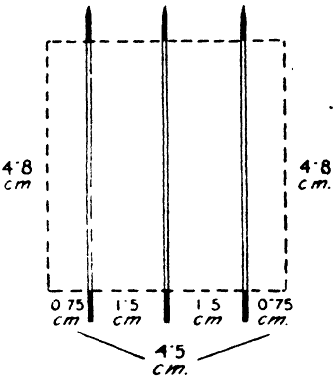


Fig. 568.—Diagram showing ideal distribution of radium needles.

The interstitial use of radium and radon is not a purely radiological problem, because its successful application demands a considerable knowledge of both clinical and technical surgery. Still further may it be claimed as a weapon in the surgeon's hands because experience is showing it to be capable of useful combination with pure surgery in many ways. Thus, radium treatment not infrequently produces very great shrinkage and localization of a previously diffuse growth, but has to be followed by surgical removal of a residual tumour. Sometimes the primary lesion is treated with radium only, and the lymphatic areas by surgery. Alternatively the primary lesion may be extirpated surgically, preferably by the diathermic needle, and the lymphatic areas treated by radium. The radium may be inserted at the time of the operation, or this stage of the treatment may be delayed until healing is complete. Interstitial irradiation may also be used, like X-rays, as a prophylactic treatment, after the performance of a radical operation. Certain advantages may be claimed for this, as, for example, after the radical operation for carcinoma of the breast, since the radium may be implanted in certain positions, above the clavicle and in the intercostal spaces, where operation cannot reach.

The uses of radium in surgery are therefore numerous and claim the close attention of every surgeon who wishes to perfect his knowledge of his craft. It cannot, however, be too strongly emphasized that the greatest benefit will be obtained from radium only where the surgeon can obtain the closest co-operation with the radio-therapeutist, physicist, and pathologist. Radium demands, in fact, a team of experts for its administration if its dangerous potentialities are to be eliminated.

CHAPTER XXVII

OPERATIONS ON THE SKULL AND BRAIN

By GEOFFREY JEFFERSON, C.B.E.

INTRODUCTION

THE tumours which arise from structures within the cranium are varied in their histology and life history. They comprise some 15 varieties, ranging from completely benign neoplasms (such as the pituitary adenomas, the acoustic neuromas, most of the meningiomas, and some of the gliomas—especially the cerebellar hæmangioblastomas and astrocytomas) to others so malignant that they are not worth operating upon (e.g. the glioblastoma multiforme). Even these last are only locally malignant ; gliomas can only metastasize if they have access to the cerebro-spinal fluid, and meningiomas only if they invade the dural sinuses. As a surgical generalization, it is no great matter whether a tumour which does not seed itself elsewhere is essentially benign or malignant so long as it can be removed with a reasonable margin of healthy tissue around it. The brain presents the anomaly of relatively benign tumours causing death because they are inaccessible (e.g. the meningiomas of the clivus) or because they arise in an area so physiologically important that they cannot be excised by block resection (e.g. gliomas involving the motor and speech areas). It must ever be a matter of chance whether the tumour lies in such a position that it can be radically attacked. The malignant glioblastomas have a habit of infiltrating the temporal lobe, the insula and basal ganglia, and of cutting the motor and sensory projection fibres, very rarely occupying the polar position that would give the best chance of radical extirpation. Dealing with this type of tumour, Dandy has removed the whole hemisphere, hoping for radical cure, but the basal ganglia had to be left behind and his patients died of recurrence. I have no doubt that malignant gliomas should not be operated upon. The real menace to the beginner in neuro-surgery are those who put pressure on him to operate upon the most hopeless cases ; and he will be fortunate if he sees other varieties except in special hospitals (or those with special services). The benign tumours often give little evidence of their presence, even less of their position ; it has become almost a proverb to say " the more difficult a tumour is to localize the better the prognosis." Conversely, the malignant tumours are easily diagnosed even by those with little special knowledge. Naturally there are exceptions to both these generalizations.

PRINCIPLES OF NEURO-SURGERY

It is possible to define certain principles for the successful handling of intracranial tumours. Amongst them are these : that the lesion should be accurately localized both as to situation and extent, that the approach should be so made as to expose it fully, that its nature should be recognized *in situ* so that it may be dealt with appropriately. The surgeon must be so fortified by physiological as well as anatomical knowledge that he does not inflict damage in excess of that natural to the lesion ; in other words, he must know what is the maximum good that he can expect from each individual intervention. He must see to it that every detail which can be used to build up a picture of the lesion and of its effects in all senses has been extracted beforehand, and that no detail in preparation has been omitted that might lead to defeat. Neuro-surgery demands an apprenticeship in which the neophyte learns to regard all lesions as exercises in applied physiology, and all operations as experiments, to be carried out with the greatest caution and solicitude for the welfare of the patient. For this reason an unhurried technique with the avoidance of blood-loss, the gentlest handling of tissues, and the use of the least irritating of all ligature and suture materials (fine silk) is the ideal. These principles are equally those of general surgery ; they cannot be forgotten without detriment..

The doctrine of "*primum non nocere*" is an important one for surgeon and physician alike. It must be admitted that there are times when this adage is difficult to respect. When, for example, an unexpectedly large and irremovable glioma has been exposed under high pressure and bleeds severely into itself, a paresis, previously no more than a ghost, may change into a very patent hemiplegia. Or again, the extraction of a benign tumour, which is doing little damage to neural structures as it lies undisturbed, may lead to a paresis or worse. Fortunately this latter type of complication generally clears up in a short time. Such happenings are distressing to everybody (not least to the patient) but are the inevitable result of the invasion of surgery into tissues highly charged with function.

In the pages which follow it has not been possible to give a full description of all operations, or even of all which are reasonably common. The surgery of access has been described in some detail, also that of a few of the more widely known conditions. Even so, the description of the actual attack on the various tumours is wanting in detail, for divergences from the typical are so common that a proper account would consist in each case of a number of detailed examples of actual instances. It is hoped that those who wish to learn more may be stimulated to acquire that knowledge by a proper discipleship.

DIAGNOSTIC PROCEDURES

VENTRICULOGRAPHY

Although it is possible in the majority of cases to localize an intracranial tumour from the history, neurological signs, and X-ray evidence, there are many cases in which tumours fail to give those classical signs of localization which surgeons feel they have a right to expect. The surgeon needs to be more exact than the physician in defining the precise situation of a tumour, for his is the responsibility for the correct attack. If the presence of a tumour is the only certain fact, while its site is clinically debatable, mechanical diagnostic means must be used. Many data can be obtained by ventriculography: (*a*) it may confirm the tentative diagnosis already made; (*b*) it may upset the diagnosis and provide information leading to a more exact approach; (*c*) it may bring to light unmistakable evidence of the nature of the lesion; or (*d*) it may rightly deter the surgeon from operating at all by disclosing diffuse neoplastic spread, say, across the mid-line. The indications for ventriculography can therefore be stated in very wide terms: it is a means for the exact definition of the situation, relationships and extent of a space-occupying intracranial lesion. It might be thought that, as the surgeon became more and more experienced, he would require adventitious aids less and less. This would be true if they gave no other information than the position of the lesion. In my service ventriculography has been employed 41 times in the last 100 cases; 36 of the remaining 59 were either pituitary or posterior fossa tumours where the diagnosis was not in doubt. It has been used so often because of its total value, as distinct from its use in localization alone.

Technique.—The operation on adults is invariably performed under local anæsthesia with the patient seated in the dental chair, after the preliminary administration of morphia gr. $\frac{1}{6}$, atropine gr. $\frac{1}{100}$ (the atropine diminishes vomiting) or, when further operation is to follow, omnopon gr. $\frac{1}{3}$ and scopolamine gr. $\frac{1}{300}$. In children general anæsthesia is necessary. The head-rest should be fitted against the mastoids rather than the back of the head. It is the custom to burr two holes and to tap both ventricles. Originally only one hole was made, but the air may fail to pass from one ventricle to the other owing to air locks, and then filling is uncertain and interpretation fallacious.

Incision.—The burr-holes are made posteriorly, 7 cm. above the inion and 3 cm. to either side of the midline. (Fig. 569.) The original practice was to make them much lower, but such punctures sometimes damaged the visual cortex and optic radiation, with results sufficiently disturbing to force the puncture to the higher and safer level, which lies between the visual and motor areas in the posterior part of the parietal association field. With the patient sitting up, and with the head unencumbered with drapes, two horizontal incisions are marked out with iodine at the site indicated. After local infiltration, a horizontal incision 3 cm. long is made between compression swabs down to the bone at the marked site. A self-retaining retractor is at once inserted and this as a rule completely stops bleeding. If any vessel gives trouble, it is picked up separately. When the pericranium is pushed aside a portion of the lambdoid suture is generally seen; it is an excellent place for a drill hole because its digitations hold the point of the perforator and symmetrically placed holes are easy to make. The bone is drilled and burred through in the direction which the cannula is to follow. The fine scale of bone covering the dura, which the burr leaves so neatly, is next elevated. Both holes are made before ventricular puncture. The dura is inspected and, any vessel that requires coagulation having been attended to, a cruciate incision is made over the whole width of the opening. Too small an opening grips the cannula so that its direction cannot be properly controlled and, further, makes it very difficult to tap the ventricle later in order to release the air. Cortical vessels must be avoided or coagulated, otherwise troublesome hæmorrhage may necesitate further bone removal to control it. The cannula is now introduced, first on the supposedly normal side. The direction of its entrance is important (*see* Fig. 569). It is directed

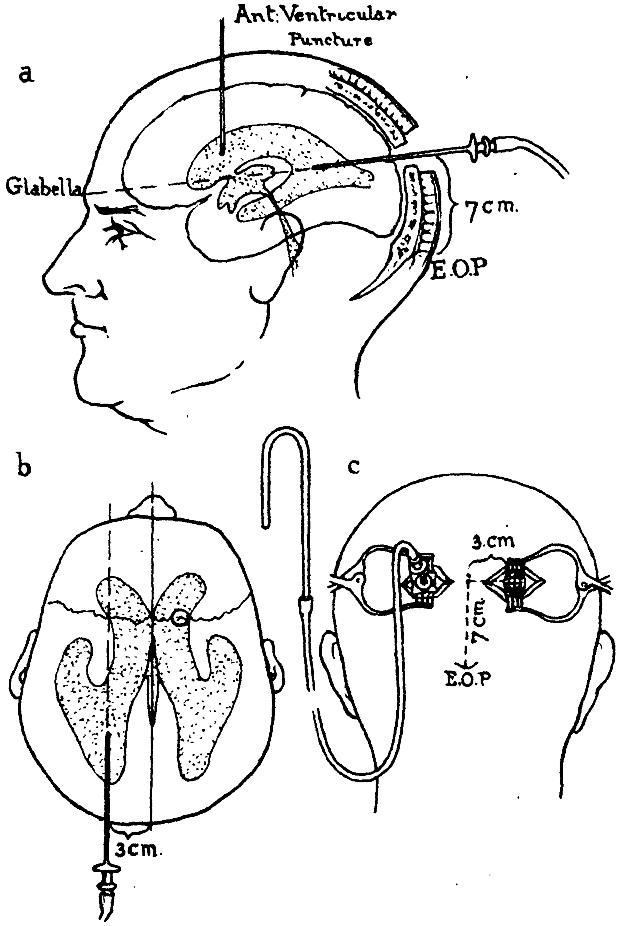


Fig. 569.—Ventriculography. Bilateral posterior puncture. Ventricular estimation with U-tubes. Site of anterior puncture also indicated.

straight forwards in a plane just above the top of the ear, so that it points (*a*) roughly level with the glabella and (*b*) laterally in line with the pupil. The ventricle is encountered at varying depths according to its size. In cases of advanced hydrocephalus it may be met with only 3 cm. from the dura, ordinarily the distance is 5 to 6 cm It is usually possible to tell by touch when the cannula pierces the ependyma to enter the ventricle. The stylet is momentarily removed, to verify the fact that the cannula is in the ventricle, and immediately replaced, so that cerebro-spinal fluid is not lost. The other ventricle is then sought in the same way.

Ventricular estimation.—When both ventricles have been located, the cannulæ are each connected with a piece of fine rubber tubing 30 cm. long, ending in a fine curved glass tube (Oljenick). The cerebro-spinal fluid pressure on each side can then be read off and noted ; it varies between 0 and 1000 mm. according to circumstances. Removal of fluid from one ventricle will be accompanied by a fall of pressure in the other if the interventricular foramina and the anterior end of the third ventricle are unobstructed. In making the punctures the surgeon has already obtained an excellent idea of the position of the ventricles, while from watching the behaviour of the cerebro-spinal fluid in the tubes, he can learn something of their size and their intercommunication. The facts learned by ventricular estimation are significant rather than mathematically exact. The height of the fluid column on each side depends not only on the pressure but also on the quantity of cerebro-spinal fluid present. For example, the pressure in a ventricle might be very high but the amount of fluid so inconsiderable that it did not fill the measuring system. Pressures can only be compared when the amounts of fluid available are equal, or nearly so. Measurements, whether registering inequalities in the fluid volume of the ventricles or not, show the height of the intracranial pressure as nothing else can. Enlarged ventricles usually indicate a subtentorial lesion, but they occur also with some supratentorial conditions (e.g. pineal tumours, third ventricle cysts, gliomas of the basal ganglia, stenosis of the aqueduct). It is therefore not safe to draw a firm conclusion without injecting air. It is useful to introduce 3 c.c. of indigo-carmine into one ventricle, to see whether it can shortly be recovered from the other ; if so, communication between the ventricles is free.

Air injection.—This is done with a 10 c.c. Record syringe fitted with a two-way tap and with a short length of rubber tubing between the cannula and the nozzle. Cerebro-spinal fluid is extracted, 10 c.c. at a time, and a slightly smaller quantity of air is injected, *pari passu*. The procedure is repeated on the other side. The whole dental chair should be tilted far backwards during the replacement, so as to ensure that the air runs well forwards and that all fluid is secured. It is better to leave the cannulæ open for a moment before withdrawing them, even though air is lost. If it has only been possible to introduce a very little air, and that into only one ventricle, the other should be punctured by a fresh burr-hole anteriorly (*vide infra*). The ventricles normally each contain about 12 c.c. of cerebro-spinal fluid. In the average hemispheral tumour one ventricle is always larger than normal, so that, all told, 25–35 c.c. can be introduced. Good pictures can be obtained with this amount, but useful information is given by less. In hydrocephalic cases the fluid obtainable may range from 100 c.c. upwards. Even then it is rarely necessary to inject more than 75 to 80 c.c. ; all the information required can be obtained by moving the air about into the different parts of the ventricular system. Very large replacements (200–500 c.c.), easily made when a huge hydrocephalus is present, are usually fatal even when continuous drainage is employed afterwards or the obstruction removed. If 100 c.c. or more have to be removed to get accurate enough pictures, the cerebro-spinal fluid should be preserved and replaced after the X-rays have been taken. If, by some chance, 80 c.c. of air should not be enough, more air can be introduced. After the necessary X-ray films have been exposed, the ventricle should be again punctured to allow the air to escape ; if this is not done the pressure when the dura is opened at operation will be excessive. In making this puncture there may be difficulty in finding the burr-hole, for its centre does not always lie immediately under the closed incision. It is then necessary to remove the sutures and reinsert the cannula under direct vision. The ventricle of the side opposite to the tumour is that from which most air can be released. Alternatively a short cannula can be left *in situ* at the first puncture ; if its butt is temporarily buried it will not move whilst the pictures are taken. There must be a supply of cannulæ of different lengths so that one can be chosen that does not protrude excessively. If there is a chronic block in the iter or posterior fossa, succussion splash may be heard by the patient days afterwards. Air has been mentioned as the substitution medium throughout, but oxygen is really better. It is a simple matter to devise means by which the syringe can be filled with oxygen.

Anterior ventricular puncture.—A burr-hole is made 2.0 cm. from the midline over the coronal suture (see Fig. 569), and the cannula directed almost vertically downwards towards the base, but inclined slightly medially, though not so much so as to strike the falx. When the ventricle has been entered, the remaining steps of the air replacement are as already related. The puncture is more efficiently done if the patient is removed from the dental chair, placing him face downwards on the table, for only in this position can sufficient fluid be extracted, and the air retained in the posterior parts of the ventricles.

Difficulties.—Theoretically it should never be impossible to find both ventricles ; nevertheless, one may escape the search. Often this does not matter, because the air injected into the one may cross into the other during manipulation of the head. With third ventricle, pineal and cerebellar tumours, both ventricles are found easily, in the same situation on either side and at the same depth. When the tumour is frontal, the posterior horns and trigones are usually not displaced; if one of them is out of position and the tumour is later shown to be well forward, this is a bad sign prognostically, for it points to a diffuse lesion or to widespread œdema. When the tumour is more posterior in the hemisphere, or temporal, the ventricle is almost always out of place, and must be sought nearer the midline. The surgeon is always gratified when the ventricle is struck with the first puncture; sometimes it will only be found after three or four attempts. More than this should not be made. Each successive attempt must be deliberate, after taking careful bearings on direction. It is my practice to place only one, thin, folded, wet towel, 6 in. wide, across the vertex so that perfect orientation can be maintained throughout. If necessary, even this towel can be removed. Sometimes fluid begins to flow from the cannula at a great pace, suggesting abundant reservoir, and then suddenly stops. This is characteristic of the small ventricle on the side of a tumour, and it is generally useless to move the cannula about trying for more; the cerebro-spinal fluid merely becomes stained with blood. If there is bleeding it is better to leave the cannula *in situ* and to keep it still. A little air can be introduced even if the ventricle is very small indeed, and it is best then to withdraw the syringe and cannula together. In the course of the punctures the tumour may be encountered as the needle enters. A meningioma is recognized by its resistance, a gliomatous cyst by the yellow fluid which escapes, a glioma by an alteration in the resistance. If a cyst is located, it is a help to fill it with air or to inject about 2 c.c. of thorotrast into it (Dott). It is unwise to move the cannula about if it strikes a glioma for this may cause hæmorrhage.

The actual interpretation of ventriculograms is not always easy, and close collaboration is necessary between the surgeon and the radiologist. Search must be made not only for alterations in the lateral ventricle contours but for filling defects and displacements of the third ventricle, the iter, and fourth ventricle. It is beyond the scope of this section to discuss the character of these changes.

Complications.—The question of complications after ventriculography brings up the rule that it should be followed at once by the appropriate operation. Only thus can fatalities be avoided, though it is true that, if this plan is adopted, the mortality of ventriculography becomes submerged in that of the surgery of the tumour. Occasionally operation may be deferred to another day, especially if the patient is tired out by the proceedings in the X-ray room. The plain fact is that no one can foretell what will happen in each and every case; ill patients sometimes survive a delay, whilst those in better condition may unexpectedly succumb. But, in general, the more ill the patient, the less safely can he be left. The most potentially dangerous subjects are those with temporal tumours, those with violent intermittent headaches, and those with severe pain in the neck, for then a pressure cone is probably forced into the tentorial hiatus, compressing the mid-brain, or a cerebellar cone into the foramen magnum. Ventriculography is then hazardous, and no case can be left without operation at the earliest moment possible.

Operation may be deferred with comparative safety in extremely well subjects, with slight or absent pressure signs; or where hydrocephalus is present. The time before operation can be spent in decompressing the ventricles by drainage with the finest rubber tubing introduced through the puncture hole on the stylet of a brain cannula. The escape of cerebro-spinal fluid can be slowed by partly closing the free end of the tube with a stitch. If carbolized dressings are used there is little risk of infection. Some patients have been so exhausted by the prolonged manœuvres in the X-ray room (an hour or even two may elapse before the radiologist is satisfied) that it may appear relatively safer to defer the major operation. As a general principle I must re-affirm the rule of following ventriculography with an operation for the relief of the condition which has made the proceeding necessary, and add that, as a matter of experience, this rule can occasionally safely be broken.

ENCEPHALOGRAPHY

The replacement of cerebro-spinal fluid by air through a needle instead of through burr-holes is a simple surgical procedure. Air can be injected either (*a*) by cisternal or (*b*) by lumbar puncture. It is very useful when information is required concerning the ventricular and cortical patterns of epileptics or concerning the basal cisterns (as in arachnoiditis, in gliomas of the optic chiasma, pituitary adenomas and optic atrophy of uncertain ætiology). A lumbar puncture must be made on a previous occasion with the patient lying on the side, the cerebro-spinal fluid pressure recorded on a manometer, and all possible information extracted from the fluid cytology, chemistry, gold curve and Wassermann reaction—before anything further is undertaken. Oxygen is better than air for encephalography, especially by the lumbar route, because considerably greater quantities of gas are required than are needed for ventriculography, and oxygen is absorbed much more quickly than air.

Technique. (*a*) **The cisternal route.**—This procedure is preferable to lumbar encephalography because it upsets the patient less and the ventricles fill more easily. A rise of intracranial pressure used to be regarded as an absolute contra-indication to encephalography. When encephalography was done by the lumbar route the fear was that tonsillar herniation might be present, and the dangers of lumbar puncture then are well known. The situation is different with cisternal (as distinct from lumbar) puncture. If a cone is present, no fluid can be extracted from the cistern and no damage is done. In some clinics cisternal encephalography is now preferred to ventriculography, which is reserved for " failed cistern punctures " and for those with known posterior fossa lesions. That considerable experience with cistern puncture is necessary before pneumograms are regularly made by this route is self-evident, especially if its use is extended to neoplastic cases. But I have become convinced by experience that it is a safe, practicable and advantageous method, the dangers of which are, in skilled hands, more theoretical than real.

The operation is done with the patient sitting. He may be propped against the head of the bed, which is wheeled into the operating theatre, or he may be seated astride a chair. The former is preferable, as the neck is easily accessible above the bed rail and the patient is more comfortable and assured. The head is supported by an assistant, whose duty it is to hold it slightly flexed and unrotated. A point half way between the external occipital protuberance and the spine of the axis is novocainized and a graduated lumbar puncture needle inserted in the direction of the glabella. (Fig. 570.) If the needle has been inclined too sharply upwards it will strike the skull base behind the foramen magnum ; the direction must then be corrected. If the aim is accurate the occipito-atlantal ligament is reached at a depth of about 5 cm. (in very muscular men 6 cm.). The engagement of the point of the needle is recognizable because it feels fixed ; previously it could be moved about. This is the only sure guide to depth ; it may be reached at less than 5 cm. After the ligament is reached a further advance of two or three millimetres carries the needle point into the cisterna magna. A depth of 6·5 cm. must not be exceeded. In a non-neoplastic case the cerebro-spinal fluid pressure may be zero or

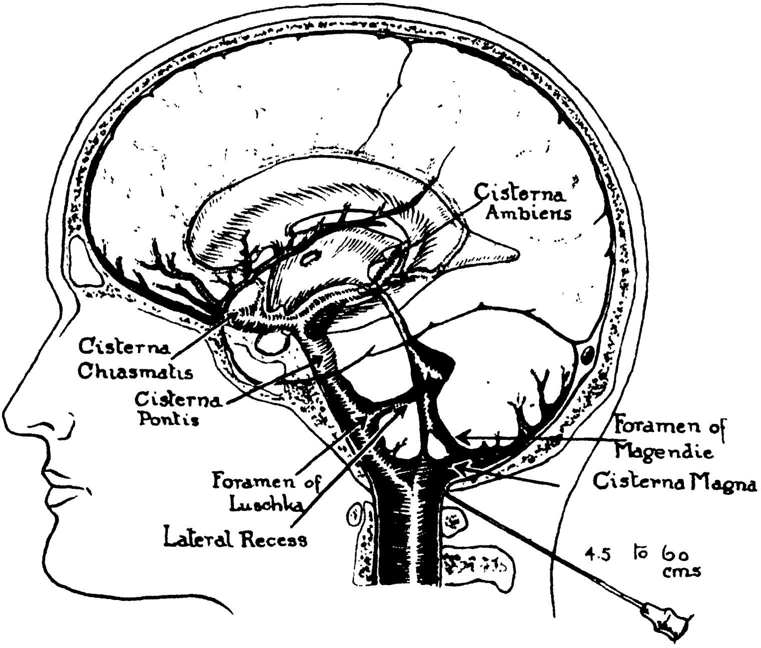


Fig. 570.—Encephalography by cisternal puncture. Ventricles and chief cisterns shown.

less in the erect posture, so that no fluid emerges; it is therefore important that the correctness of the positioning of the needle tip should be verified by aspirating with a syringe. This is important. When pressure is raised, fluid drips out at once. Ten c.c. of fluid are extracted and 10 c.c. of air or oxygen then introduced. This is repeated until 30 c.c. have been injected; sometimes considerably more can be introduced, depending on the amount of fluid obtainable.

I have never seen trouble follow cisternal puncture, even when cerebellar tumours were present. No fluid can then be obtained and there is an end of it; ventriculography must be performed. The failure to obtain fluid has, meanwhile, given an important clue.

(*b*) **The lumbar route (patient sitting).**—This is the safer method for the beginner, though much more disturbing to the patient, who almost invariably becomes shocked and sick at some stage of the replacement. The reason why lumbar insufflation is so much more disturbing than cisternal is because the whole cerebro-spinal fluid column, from the vertex to the level of puncture, is interfered with, whilst the cisternal route leaves the spinal portion undisturbed. Although the patient may feel very ill and complain bitterly of headache, no harm ensues, nevertheless there is much to be said for the administration of an intravenous anæsthetic (evipan or pentothal-sodium) for the operation. The difficulty then is to support the patient in the requisite sitting position with the head upright, but this can in practice be readily achieved.

The patient sits on the operating table, his feet on a chair at the side. The back is flexed whilst the puncture is made, after which a more upright posture is assumed with the head erect and chin down. The first step is the injection of 10 c.c. of oxygen at the usual level of lumbar puncture (L. 3–4) before any fluid is withdrawn. This will most probably enter the ventricles, for the cerebro-spinal fluid dynamics have not been interfered with. Ten c.c. of fluid are now allowed to run away and a further 10 c.c. of oxygen injected; the process is repeated until the required total has been reached. Good pictures can be obtained with 40–50 c.c., but if every possible item of information concerning the ventricle, cisterns, and subarachnoid spaces generally is to be obtained, the procedure must be carried on until all the easily available fluid has been removed. This may require the abstraction and injection of from 80 to 140 c.c. My own practice is to use 45 c.c. and to inject more if this proves insufficient, which is rare.

Difficulties and complications.—It is wise to move the patient's head about during the injection because in some persons the air goes over the cortex much more readily than into the ventricles, and this may hold true even on repetition. There is no universally applicable reason for this. Good ventricular outlines may be secured with no more than 25 c.c. if all the air happens to go inside, but in order to make certain of clear pictures of the meningeal spaces and ventricles, larger rather than smaller quantities must be employed.

The only sequelæ of encephalography are shock and very bad headaches, worse if the gas is chiefly in the meninges, and much less obtrusive after cisternal insufflation. The discovery of an unsuspected tumour would be an indication for immediate operation. The surgeon ought not to be taken unawares in this fashion if he has studied the case beforehand as fully as he should have done. Patients need a good deal of sympathetic attention and nursing comfort during the first hour or so after the radiographs have been taken. It is an advantage of avertin or pentothal that the patient remembers little of his acutest discomfort, though he does not escape all headache.

Oxygen is absorbed very rapidly, air more slowly because of its nitrogen. The disappearance of air can be hastened by breathing concentrated oxygen from a close-fitting mask, such as the B.L.B. type. This reduces the nitrogen tension in the blood circulating through the lungs and thus renders more rapid the passage of nitrogen from the subarachnoid spaces into the blood. The greatest absorption of either oxygen or nitrogen does not take place within the ventricle but after the gas has escaped on to the exterior of the brain.

ANGIOGRAPHY

Egas Moniz, of Lisbon, introduced contrast radiography of the cerebral vessels in 1927, a method that has come to be called angiography. Thorotrast (thorium dioxide) is the substance now used, in place of the iodide solutions originally employed, and abandoned because of their tendency to provoke immediate convulsions. The radio-activity of thorotrast tends to damage the reticulo-endothelial system, but so far no convincing proof has been brought forward that harm comes from the quantities used in angiography.

Indications.—(*a*) It is possible to prove the existence of abnormalities of the cerebral vascular tree, such as aneurysms. In regions other than the brain, aneurysms are becoming great rarities. The vast majority of those which arise from the carotid artery and its branches and on the circle of Willis are non-syphilitic and are due to congenital weaknesses of the arterial walls. When they spring from the carotid trunk they demand surgical treatment, the nature of which depends on the site and size of the lesion (*see* p. 1255). The necessary facts concerning the aneurysm can be learned only by angiography. (*b*) The second indication is for the demonstration of another vascular anomaly—racemose angioma of the brain, a not uncommon cause of focal epilepsy. (*c*) The third indication, of which great use has been made, especially in some Continental clinics, is the localization of cerebral tumours. In certain respects the information given by angiography is superior to that given by ventriculography. Owing to differences in the vascular supply of the meningiomas and gliomas, and of subdivisions in the latter group again, it is frequently possible to determine the nature of the tumour as well as its site. Angiography has the advantage over ventriculography that it can be used in cases of high intracranial tension without fear of upsetting the blood and cerebro-spinal fluid balance, and therefore need not be followed by immediate operation. Ventriculography has the disadvantage that it is apt to commit the surgeon to operation, even if he is very doubtful whether the condition disclosed is amenable to surgery.

Technique.—Under local anæsthesia (after pre-operative omnopon gr. $\frac{1}{3}$, scopolamine gr. 1/300) the internal carotid artery of the suspected side is exposed in the neck through the usual incision. After it has been isolated and under-run with a silk ligature, so that it can be drawn up towards the surface, the patient is taken to the X-ray room. It is helpful to put a stitch into the sterno-mastoid so that it can be retracted without instruments, all of which are removed. The patient is placed into position on the X-ray couch with the head turned fully to the opposite side. It does not matter if the artery nearest to the film is not the one being injected. The first film having been placed in position beneath the head, the artery is punctured with an ordinary Record needle (which can be bent in the fingers to a convenient curve) attached to a 20 c.c. Record syringe by a short rubber connection. The syringe is not quite filled with thorotrast so that a little blood can be aspirated to verify the fact that the needle is within the lumen of the artery. A fairly rapid injection is now made. There is no necessity to use great force in introducing it, but it must not be slowly done.

When 7 c.c. have gone in, a rapid lateral exposure is made (arteriogram) followed by a quick film change and a second lateral exposure 4 seconds after the first (phlebogram). An antero-posterior view is now taken. A second syringe is attached to the needle in the artery (which is not meanwhile disturbed by the necessary changes in position of the head, owing to the flexibility of the rubber connection), another 7 c.c. of thorotrast is injected, and an exposure made. The needle is finally withdrawn from the artery and a swab pressed on the point of the puncture.

Such bleeding as there is soon stops, though I know of one case in which the artery bled so furiously after the needle was taken out that it had to be tied, fortunately without ill effect. It would be better to close the hole with fine arterial silk sutures. The artery should be carefully inspected before it is punctured; if it looks brittle or has plaques in its wall the surgeon had better close the wound and not tempt fortune. With curved needle and a rubber connection between syringe and needle there is very little risk of converting the puncture into a small tear. It need hardly be said that a shockproof X-ray apparatus is almost a necessity, and that a special casette is needed to allow a very rapid film change.

GENERAL TECHNIQUE

BLOOD LOSS

The care needed to minimize hæmorrhage during entrance is referred to repeatedly in these pages. Operative exsanguination was the chief reason for the two-stage interventions of earlier days of neuro-surgery when the anæsthetist's finger on the pulse, rather than ocular demonstration by blood-pressure records, gave the clue to the amount that the patient would stand. The appended list of accurate measurements by H. J. Brennan on my own cases, confirming J. C. White's figures, may help the reader to understand the necessity for caution. Scalp, bone, tumour and brain can all bleed profusely.

Nature of Lesion	*Blood loss in C.C.*
Frontal astrocytoma	915
Temporal astroblastoma	1102
Pituitary adenoma	709
,, ,, ...	645
Parietal meningioma	987
Basal meningioma	1500
Falx meningioma	929
Acoustic neuroma	1162
Trigeminal neuralgia	162
,, ,, ...	158
Parietal meningioma	987
,, ,, (2 days later) ..	1505
Cerebellar astrocytoma	946

The patients survived these losses, but these figures compare strikingly with the 40 c.c. lost during the repair of an inguinal hernia or an appendicectomy. Some of the more formidable general surgical operations, notably radical breast amputation and some thyroidectomies, cost of over 500 c.c. Reduction of the blood volume by 800 c.c. (about $\frac{1}{6}$th of the total) is well enough tolerated, but some patients, in poor general condition beforehand, require transfusion after hæmorrhages no greater than this. During long operations the insensible fluid loss from skin and lungs may amount to 2,000 c.c. as J. C. White has shown, but this alone is not a very serious factor though it must have some effect.

Blood counts, hæmoglobin estimations and blood-pressure records should be made pre-operatively on all cases. In patients who have vomited frequently and been unable to eat, the blood protein and sodium tallies fall below safe levels, hence the need, when possible, to feed an ill patient for a few days to correct this condition before operation. During the operation systolic and diastolic pressures, the pulse and respiration rates, are recorded on a chart every ten minutes. A graphic record is the only way of estimating the patient's condition with accuracy ; only thus can the surgeon forestall one of those precipitous drops in pressure causing sudden alarm. Blood transfusions must be used freely ; in one case recorded in the list above (loss 2492 c.c. in 48 hours) the patient had five transfusions of between 500 and 600 c.c. each and survived.

The necessary speed in replacement can only be secured by careful planning beforehand. Some tumour removals are easier after the blood pressure has fallen ; gutting a vascular tumour or securing vessels is made simpler when the force and speed of the blood flow is diminished. But, although all may go well with the systolic pressure at 80 or less, the subject can no longer respond to a sudden hæmorrhage, such as may mar the last stages of the dislodgement of a meningioma. Not only must blood be waiting in the theatre but the cannula must already be in a vein so that immediate restoration can be brought about. The modern availability of blood has played no small part in the increased resources of neuro-surgery in dealing radically with tumours. Even so, the problem of hæmorrhage is more than one of emptying and filling the vascular system ; red cells tend to become lost, as they do in shock and, although transfusion will remedy a single bleeding, it loses its effectiveness when the bodily resources are severely tried by repetition. The ideal is to replace from the outset.

ANÆSTHESIA

The relative merits of the different forms of anæsthesia are still debatable because there are objections to all : a method favoured in one clinic is anathema in another.

A. **Local anæsthesia.**—Local infiltration with novocain-adrenalin or its equivalent is the ideal method, because it allows the surgeon to follow the physiological effects of his operation as it proceeds, and to observe the clinical state afterwards. It is a mistake to try to get the advantages of general anæsthesia by heavy pre-operative medication. Morphia gr. ⅙, repeated if necessary, is sufficient. Olivecrona advocates, in addition, luminal, grs. 5 overnight and grs. 3 in the morning, to ensure a light sleepiness that never causes the profound fall in blood-pressure which sometimes occurs with avertin. Nor is the patient ever so unreasonable, or indeed unmanageable, as he may become with the latter. I have found this plan good. Painful stages in the operation can be tided over by the exceedingly slow intravenous injection of evipan or pentothal. In this way formidable procedures can be successfully carried through. Local anæsthesia has every advantage in some directions, but faults in others, e.g. the patient may become restless and unhappy, because of his immobility or discomfort, no less than because of apprehension at what he can hear (bone-drilling, sawing and so forth) ; it is impossible to get muscle grafts from the leg without upsetting him by an infiltration that must be wide, and he is aware of incisions about the ankle for transfusions and so forth. Evipan overcomes these disadvantages. Post-operative mortality is lower and after-care is very much simplified in local anæsthesia, so that it remains a most important method.

If inhalation anæsthesia is preferred there is a choice of several.

B. **Intratracheal ether and oxygen** has been widely used in America and to some extent in England. The risks of explosion when diathermy is used seem negligible if macintosh sheets and wet towels are applied to shut off the operation field. The anæsthetic machines should be periodically examined for leaks. The disadvantages are that the necessary atropine in some patients dangerously increases the pulse-rate and that ether increases the blood flow through the brain and also causes vaso-dilatation. But of all the inhalation methods it is the least likely to cause either anoxia or hypercapnia if a perfect air-way is maintained. This needs watching ; a mouth tube should always be inserted to prevent the patient biting a transbuccal endotracheal tube, and in any case to ensure free breathing. The free secretion of mucus caused by ether may block the endotracheal tube.

C. **Chloroform** is too depressant to be advised, but in highly skilled hands it is, in fact, sometimes employed but rarely alone or for all the time.

D. **Cyclopropane** is too inflammable for neuro-surgical operations, except in closely sealed circuits. Trilene is gaining in favour but must not be used with re-absorption apparatus.

E. **Nitrous-oxide and oxygen.**—Physiologically this excellent anæsthetic possesses serious faults. If the oxygen content is less than 20 volumes per cent., anoxæmia may result, but not certainly so ; below 10 per cent. it is certain. With less than 90 per cent. of nitrous-oxide the patient cannot be kept quiet unless he has had morphia, avertin, or some other basal narcotic which might depress his respiration, blood pressure and cardio-vascular efficiency to an anoxic level. Experience shows that this does not always happen, but it may happen, and at present there is no way of foretelling which patients are unduly susceptible to avertin, evipan, pentothal and the like. The situation can be summed up by saying that in the majority of cases avertin (80 mgm. per kilo of body weight), even with a dose of omnopon-scopolamine in addition an hour beforehand, and nitrous-oxide-oxygen gives an ideal anæsthesia, but that at long intervals a case will go badly wrong. It is most unsafe with posterior fossa tumours. Under endotracheal ether-oxygen mishaps are rarer, but they will still occur at times, for even ether can cause anoxia.

It emerges that no type of anæsthesia is perfect ; of those available, local anæsthesia or ether-oxygen by the transnasal endotracheal route are the best for operations on the cerebral hemispheres in co-operative patients, the latter for operations in the posterior fossa. Nitrous-oxide-oxygen can be used in clinics with special experience of its values and disadvantages.

ANOXÆMIA AND HYPERCAPNIA

All four of Barcroft's types of anoxia are seen in cerebral conditions : (1) stagnant anoxia, where the blood current is slowed by local compression of vessels or by the surgical occlusion of large veins (e.g. the parasagittal) in the removal of tumours ; (2) anæmic anoxia, where the hæmoglobin content of the blood is too low to allow efficient oxygen carrying, as in patients in poor general conditions or in those who lose excessive quantities of blood in the course of the operative procedures; (3) histiotoxic anoxia, when the cells are damaged and are unable to use oxygen, as in some patients susceptible to barbiturates or patients who are dehydrated by vomiting or are otherwise toxic; (4) anoxic anoxia, which may be (*a*) generalized, due to insufficiency in the available supply of oxygen, as when breathing is too shallow or slow, or (*b*) localized, as when an area is surgically deprived of its blood supply but not excised. Some of these anoxic effects are primary, others develop secondarily as the result of unavoidable surgical manipulations or from anæsthesia. A deficiency in oxygen in the blood, either local or general, increases the capillary permeability, first to fluids and crystalloids, later to the larger protein molecules and to the blood cells themselves, leading to perivascular hæmorrhages. When generalized, tissue anoxia damages everything, brain, lungs, liver, kidneys, the endocrine glands; when local, the effects are limited to the brain itself and its seriousness will depend on the area rendered anoxic. Thus, if the motor area is anoxic, paresis results from the œdema set up; if there is oxygen lack in the hypothalamus, mid-brain or medulla, a rapidly fatal hyperthermia follows.

The effects of increased carbon dioxide (hypercapnia) are more dramatic and temporarily more severe, but fortunately more reversible. An elevation of carbon dioxide tension in the inspired air causes immediate swelling of the brain with vaso-dilatation, the blood volume within the skull being considerably increased (as Forbes, Lennox, Gibbs, J. C. White *et al.* have proved). Conditions of that kind are the worst possible for efficient cerebral surgery, the cardinal principles of which are to have (*a*) a good exposure and (*b*) as lax a brain as possible. Defects in respiration, as in fourth ventricle tumours, lead to insufficient ventilation in the lungs and accretion of carbon dioxide in the blood, as well as to anoxia. Both anoxæmia and hypercapnia may exist independently.

The physiological ill-effects of anoxia and hypercapnia sound so bad that the reader may wonder why any patient survives an anæsthetic or an operation. The facts are, naturally, that in their severe forms both are uncommon, but they can be very frequent if their potentialities are not realized and the methods of reducing their incidence understood; otherwise the surgeon will find himself ruefully puzzling over difficulties or fatalities that he cannot understand and which others do not seem to encounter. It is for these reasons that local anæsthesia, with a good oxygen supply under the towelling, is pre-eminent, and a surgeon who has had a run of bad cases will do well to revert to it.

OPERATION IN STAGES

One-stage or two-stage operations.—The pioneers of the surgery of the brain usually operated in two stages, cutting a bone flap or, more usually, removing the bone entirely (Horsley) one week, and dealing with the tumour the next week. This practice has fallen out of favour because improvements in anæsthesia, the modern prevention of hæmorrhage and the use of blood transfusion allow much longer sessions to be carried through successfully. There are occasions when the operation is better done in stages, usually for meningiomas. But two things are necessary, two very important things: (1) that the wound shall be fit to re-open; (2) that the patient shall be ready for the second stage in as good condition as he was for the first. In my own hands the only cases deliberately staged have been meningiomas with X-ray evidence of extreme vascularity or with large hyperostoses. It is true that very occasionally I have found it necessary to break off an operation because of exceptional difficulties or an unexpected falling-off in the condition of the patient, but these events cannot be reduced to dogma. The chief concern in the staged operation is: will the skin be fit for re-opening, even if the greatest care has been taken? The answer is usually yes, but the slightest morbidity or moisture causes anxiety. If the operation is to be done in two stages, when should the second stage be undertaken? There is no rule but one: the sooner the better. For instance, a second stage has been performed in my clinic later on the same day (successful removal of a large meningioma by Rowbotham) or next day. In one case a stage was done every other day for six days, until an excessively vascular outer sphenoidal wing meningioma was removed, with complete and lasting success. These cases are mentioned to show that there is no hard and fast rule, and that logically the patient is ready for the next stage the moment he has *recovered* from the last.

LENGTH OF OPERATION

At this date there is no need to defend careful surgery, which must always be rather slow. There is no virtue *per se* in taking a long time over an operation, but the special difficulties of entrance and the necessity for extreme care in closing the wound demand time in neuro-surgical interventions. It is easy enough to operate quickly, but it nearly always entails roughness and corner-cutting, which is gambling. The spectacular operation appeals only to amateurs. Nowadays only the uncommon case lasts for over 2½ or 3 hours, and some can be done in much less time. The Halsted technique, applied to neuro-surgery with such outstanding success by Harvey Cushing, remains, in the belief of many, the best ever devised. It consists of extreme gentleness of handling, absolute hæmostasis at all stages of the operation, perfect apposition of tissues, and the use of that ligature and suture material which causes least reaction in the wound: iron-dyed fine waxed silk. A perfect operation ought to look like a superb physiological experiment (as indeed it is), the object being to inflict the least possible damage on the patient, whose recovery in the best imaginable condition is the essential object of the proceeding. With modern methods of anæsthesia no harmful effects can be traced to the time factor, except the possibility of infection, and certainly a very high standard of combined asepsis and antisepsis is needed. An occasional successful operation of ten hours has been reported. We may well marvel at the fortitude of the team, but we should equally applaud the perfection of operating-room management that made possible so long an exposure without bacterial contamination.

EXPOSURE—THE OSTEOPLASTIC FLAP

The approach to a hemispheral tumour must be made through a well-placed bone flap. To expose a tumour adequately it is essential to know its site beforehand as precisely as possible, a requirement which not uncommonly necessitates ventriculography. The flap must be not only correctly situated, but of sufficient size to allow the manipulations proper to the individual tumour. It is the bane of brain tumour work that the surgery of access and of closure is so tedious. Unless the approach is made according to well-tried rules, the approach may leave the patient unfit for the treatment for which the operation is planned. Mechanical and electrical aids have been devised which, no doubt, suit the requirements of the inventors, but are rarely so helpful to anyone else. The most popular amongst them is the electrically-operated drill, of which the de Martel type is particularly good and ingenious. But all these drills are heavy, or if they are not heavy are rarely safe and, like all electrical equipments, they are apt to get out of order. In the end, after trying everything, I am convinced that the hand-operated Hudson perforator and burr is the safest and most generally useful method of making the necessary openings in the bone.

Position of the patient.—All operations on the brain require a special table. It need not be elaborate or costly, but only by its use can the surgeon obtain that comfortable and close approach which is a necessity. Positioning on the table and on the head-rest are most important. Attention to detail must be developed in the highest degree if a high level of success is to be maintained. An example is the need for provision of much deeper padding on the table than is provided for ordinary short operations. Patients feel the effect of long recumbencies with full muscular relaxation on insufficiently protected surfaces. The easiest position to arrange is that for the frontal flap, for here the patient lies on his back with the head raised and slightly flexed. When a lateral flap, and especially one far back, is required, there may be difficulty in obtaining the necessary amount of rotation, especially in the short-necked or muscular individual. A sand-bag under the shoulder, and a quarter-turn of the body towards the opposite side, at once remedies defective rotation of the head. Occasionally it may be a good plan to turn the patient on to his face in the cerebellar posture if an extreme occipital flap is needed. But the head often sinks so deeply into the head-rest that good access to the anterior or temporal limb of the incision cannot be obtained. The patient can well be placed on his face and the head then turned to the side on the head-rest. This is the posture I use for extreme occipital hemispheral exposures. Severe rotation of the head on the neck leads to compression of the jugular veins and raised intracranial pressure.

In general, it is best to have the head raised higher than the feet, to prevent venous engorgement. The more the head is up the better. This necessitates an adjustable rest at the foot of the table that can be slid against the soles of the patient's feet to prevent him slipping down. The legs must be strapped to the table above the knees to prevent them from bending.

Details.—After proper positioning has been achieved there are three further things needing attention. Nothing more clearly shows proper neuro-surgical training than attention to details preceding the intervention, which may be wrecked by their omission. First, the eyes should be covered with a mask of thin guttapercha tissue. A " V " is cut out for the nose and the material made to adhere by dabbing it with a swab dipped in hot water. Next, both lower limbs must be bared. To one the neutral electrode of the endotherm will be bandaged; the other, prepared over night, is exposed and towelled for intravenous transfusion and for excision of muscle if need be. Often the introduction of a cannula into a vein at the ankle should be the first step in the operation. The other important point is to see that the patient is properly oxygenated. If intratracheal anæsthesia is being used there is no difficulty, but if the operation is to be conducted under local anæsthesia comfort must be ensured. Unless there is a free air-way, unless the nose and mouth are clear, the patient soon becomes convinced that suffocation is inevitable. The way to avoid this difficulty is to arrange a tray above the chest so that the towels can be carried from the head on to it, making a tent. Wet drapes, wrung out of 1 in 1,000 perchloride, are always put next the skin. They are used because they diminish the risk of infection, mould themselves better to the head, and cling to it more closely. But if they are allowed to sag down on to the face they cause embarrassment. The operating table should have an adjustable instrument tray fixed to it; the towels are stretched on to it from the head. In an emergency the surgeon can make do with a stand-tray swung over the table, but a properly-fitted table should be used as a routine. At least two trained assistants are needed; three is a better team. If the hospital runs a transfusion service, its personnel replace one or two assistants.

Planning the flap.—The true osteoplastic flap is one in which the bone is turned down with the scalp adherent to it. (Fig. 571, d.) This is the classical procedure and a very good one, especially for meningiomas, which usually have considerable vascular connections with the soft parts overlying them. It is used in the parietal, temporo-parietal, and fronto-temporal regions. But no harm to the bone comes from stripping the skin down separately and then cutting the bone flap secondarily; nor, indeed, if the bone is completely separated from its temporal hinge, is lifted out as a " free " flap or graft, and replaced later. This is always safe. I have boiled and replaced such a flap on four occasions because it was infected with tumour; three times it was accepted by the tissues. It is clear, therefore, that in planning flaps the surgeon need not be absolutely restricted by the thought that either skin or muscle adhesion with the bone must be preserved.

(*a*) **The Trotter flap.**—This (which is known in America as the Naffziger flap) was designed as a frontal flap but it can be used to expose anterior and middle temporal as well as frontal and pituitary tumours. It is excellent also for sphenoidal wing meningiomas. It can be varied in size at will. For the pituitary adenomas it can be kept small, whereas for more posteriorly situated lesions it can be made much larger by bringing its posterior limb down behind the ear. (*See* Fig. 571, b.) The incision commences in the mid-line of the forehead an inch above the glabella. It may be started higher than this if there is no reason to expose the extreme anterior pole of the frontal lobe. The incision runs back, precisely in the mid-line until the hair-line has been well entered, and then swings away to be carried down in a curve to the temple, in front or behind the ear according to the size of flap required. The scalp is dissected off the bone and held out of the way by retractors. The bone flap is cut separately. The great advantage of this incision is that it does away with unsightly scars on the forehead, the worst of which is one running obliquely from the temporal fossa to some point between eye-brow and hair-line.

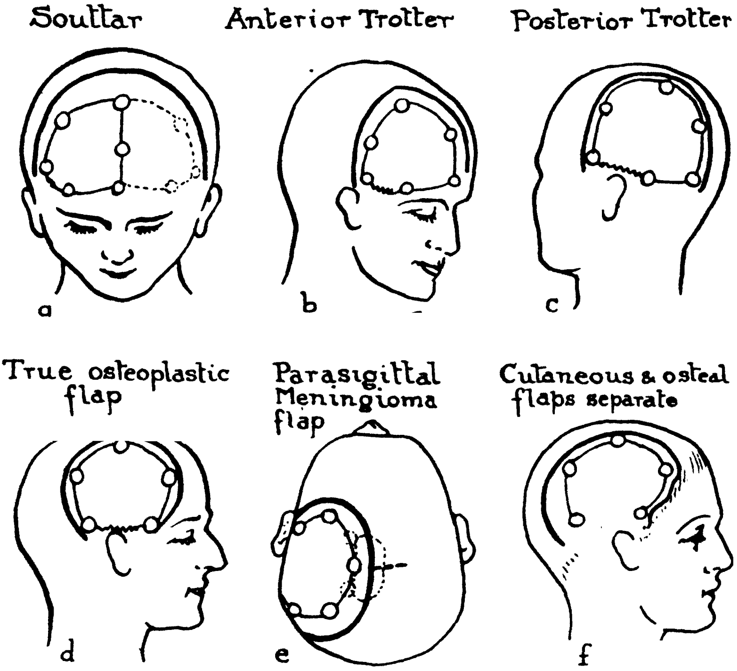


Fig. 571.—The common skin incisions and bone flaps.

So long as any incision is kept dead centred in the mid-line of the forehead and is carried up vertically the resulting scar is always insignificant. The disadvantages of the incision are two. The first is that it is difficult to get exposure low down in the temporal fossa without considerable retraction of the flap. This has not been a sufficient difficulty to prevent me from using it freely. The second disadvantage is the large dead space which results when a big flap is cut in this way, for there is then more chance of post-operative wound infection. It is well to drain into carbolized gauze for 24 hours.

(*b*) **The Souttar incision.**—This is a coronal incision across the vertex from one temporal fossa to the other. (Fig. 571, a.) The anterior flap is then dissected down over the eyes. A right- or left-sided frontal bone flap, or even both, may then be cut, the skin incision being carried rather lower on the side of access to the tumour. Its disadvantages, such as they are, are the same as those of the Trotter flap.

Lateral flaps.—For parietal flaps, which are usually fronto-parieto-temporal, the true osteoplastic flap was originally designed by Wagner. As originally planned, its omega form implied too narrow a base for the skin. Necrosis in the suture line may follow. And yet it is necessary that the base or pedicle of the flap should be fairly narrow, otherwise the bridge of bone there cannot be broken through. For that reason it has become customary to cut a semi-lunar skin flap with a wide base, making the bone-flap secondarily with as narrow a base as the surgeon pleases. (Fig. 571, f.) The only disadvantage is that implicit in the presence of two dead-spaces, one between skin and bone as well as the second unavoidable one between bone and dura (as in the flaps described above). My own experience is that there is less fear of infection with osteoplastic flaps but that the others are cosmetically better and quicker. I use either, but always the Trotter for frontal and sphenoidal ridge lesions.

The occipital flap.—A reversed Trotter does very well here. Occipital bone flaps are difficult to make because of the thickness of the skull, and more particularly because of the antero-posterior curvature of the base which renders it very unwilling to break. It is necessary to leave a very narrow unsawn bridge of bone or else fracture strains the skull too much and is intolerable for a patient under local anæsthesia. A true osteoplastic flap in this region is therefore most difficult, but it can of course be done.

Preparation of the skin.—The head is shaved the afternoon before operation and, after a thorough washing, is prepared with alcohol, and a sterile compress applied. Alcohol causes less scaling than other antiseptics. When the patient is anæsthetised the scalp is again washed with alcohol and allowed to dry. Cushing usually had his patients shaved early on the day of operation, as a newly shaven head interferes with sleep.

Making the skin-flap.—The projected flap is marked out by a wooden stick tipped with wool, or a small dental swab, dipped in iodine. This allows the surgeon to make any amendments that may occur to him when he sees how it runs over the curvature of a particular skull. It is a good plan to draw a line down the middle marking the sagittal sinus, and then to add the sulcus centralis and to rough out the temporal lobe. The line of intended incision is infiltrated with 1 per cent. novocain-adrenalin solution injected above but chiefly below the galea. It is unwise to force the solution too much into the fibro-fatty substance of the scalp itself, though some is placed there. The flap is now lightly marked out with a knife, and a large piece of lint, wrung out of 1 in 1,000 perchloride of mercury, is placed over the head and sewn on to the scalp, and the drapings are then applied. Those next to the head are always wrung out of antiseptic, for this is safer in view of the long duration of some of these operations. (The eyes, having been covered, are protected from chemicals.) The scalp must be completely exsanguinated by the pressure of the assistants' fingers on either side of the incision. (Fig. 572, A.) This is an art which requires some training. A greater length than 7 or 8 cm. at a time is difficult to control. As soon as the first length has been cut, the galea is rapidly picked up by forceps roughly a centimetre apart; and when these have been applied to both sides they are grouped together with rubber bands (*see* Fig. 572, B), five at a time being the most manageable number. A piece of dry gauze is placed in the incision and the manœuvres repeated until the whole flap has been cut. In a well-managed case there should have been next to no

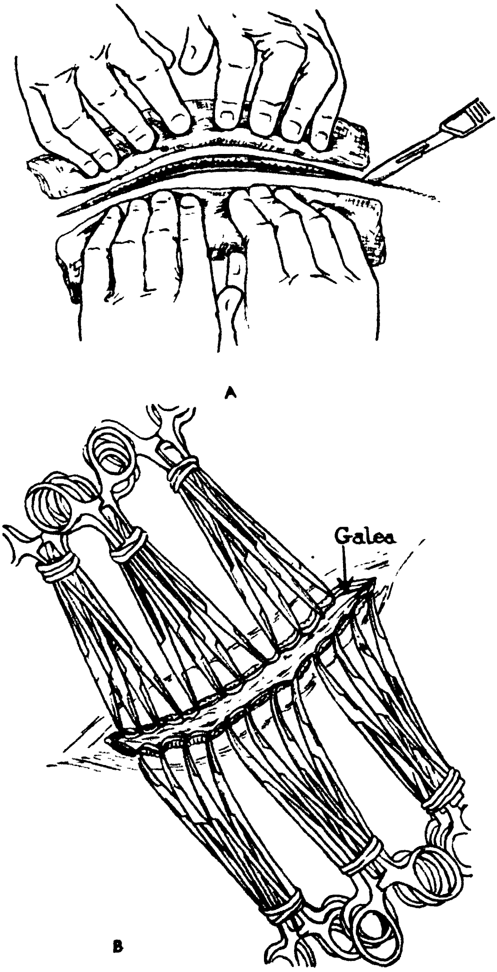


Fig. 572.—Incision through scalp exsanguinated by finger compression. Below: artery forceps picking up galea bundled with rubber bands.

bleeding during the making of the incision, a most desirable thing because the scalp is so vascular that a great deal of blood may be unnecessarily lost during this relatively trivial stage—blood that may be very badly needed before the operation is completed and the patient safely back in bed. In a test-case of mine 50 c.c. of blood were lost during what appeared to be a very bloodless entrance, and 300 c.c. during closure when the forceps were removed for suture. The scalp flap having been cut, the next step depends on whether a true osteoplastic procedure is intended, or some modification. If the former, all the parcels of artery forceps on the inner edge of the incision must be grouped neatly together and fixed upright with a long strip of gauze, or rubber bands, or both. If the latter, the scalp will be dissected down as far as required. Search must be made for any vessels that have not been secured, and any small bleeding points on the pericranium must be coagulated with the endotherm. The proposed bone flap is next delineated by incising the pericranium with the cutting current, and the membrane pushed to the sides with a raspatory to leave a fairway a good centimetre wide.

Cutting the bone-flap proper.—In general, a satisfactory bone flap is 5-pointed, i.e. five drill holes joined with the Gigli saw. (Fig. 573, b.) It is not a true pentagon, for the bevelling of the bone edges by the oblique cut with the Gigli rounds its contours. Generally, it is wider than it is high. The drilling is done with the Hudson perforator, followed by burrs, unless the surgeon insists on electrical apparatus. The Hudson burrs are excellent but must be kept sharpened and (most important) kept tapered to prevent plunging through the skull. (Fig. 573, a.) It is usual to make all the perforations first and then burr them out afterwards. Bleeding is prevented by wax, and by placing portions of dental swab in each burr hole as it is made. The next step is to separate the dura with a curved dural dissector so as to secure a safe start for the guide for the Gigli saw. (Fig. 573, c.) If there is any difficulty in introducing the guide it is best to sink other intermediate holes, especially if the flap is over the sagittal sinus, for the guide may be caught in a fold of dura. (Fig. 573, e.) The best type of guide is the de Martel, made of watch-spring with a cover for the hook to which the loop of the saw is attached. The new type of Stille Gigli saw is a remarkable instrument ; it rarely breaks and the bone can be cut with it in a few seconds. Sometimes there is very free bleeding from beneath the bone whilst the guide is in ; it stops if the guide is pulled out as soon as the saw is well sunk into the bone. Any bleeding from the line of the saw cut is diminished by forcing in bone wax.

After all drill holes have been joined, the lower ends of the incision in the bone are carried down beneath the temporal muscle with de Vilbiss forceps. The flap can now be broken back by levers inserted under the edge. Bleeding commonly occurs from the meningeal vessels, which are at once coagulated, and from the parasagittal lacunæ if the flap is carried up to the mid-line. This latter bleeding is important and must immediately be checked by strips of hot moist lintine, which soon adhere and check the hæmorrhage. If, however, the bleeding is excessive owing to an underlying tumour or an impeded airway with venous congestion (the quality of this bleeding is informative to the experienced), muscle grafts must be cut, either from the temporal muscle or from the leg below the knee.

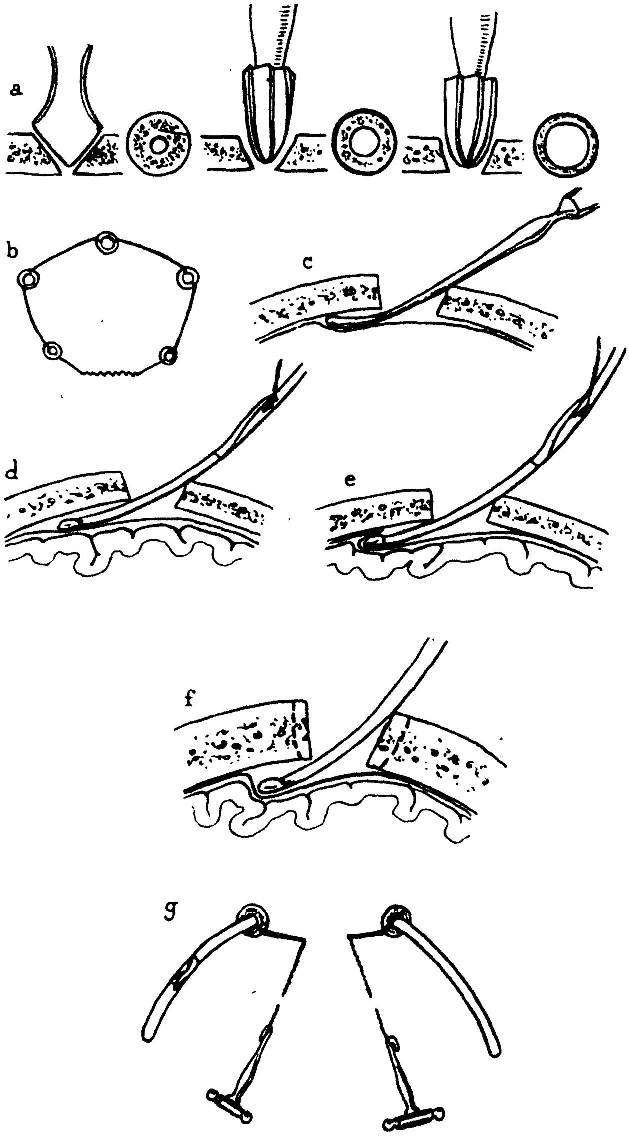


Fig 573.—The bone flap.

a, Drilling and burring. **b**, completed flap. **c**, separating dura. **d**, Gigli guide sliding in. **e**, guide catches in dural fold. **f**, thick skull causes guide to enter too vertically. **g**, joining burr-holes with Gigli saw.

By these means the hæmorrhage soon stops, but a continued ooze may come from the dura just beneath the bone edges. This can be checked by " hitch-stitches " which pick up the dura a millimetre from the bone edge ; they are left long, weighted by a pair of artery forceps. These hitch sutures may have to be inserted at several points. At the end of the operation the dural traction can be made permanent by threading a needle on to the stitch again and passing it through the pericranium and tying it. A groove may have to be cut in the bone to accommodate this suture, but not always. The dural surface should now be completely dry ; until it is, it must not be opened. The amount of blood lost up to this stage should have been little unless the patient has engorged dural sinuses or exceptionally vascular bone. The surgeon should pause for a moment to consider whether, from what he has seen already and what he expects to encounter, a blood transfusion will be necessary, and when. It is rarely required at this point except in meningiomas.

INTRA-CRANIAL PROCEDURES

Opening the dura.—The dura is incised transversely at the lower end of the incision. It is usual, before doing that, to nibble away part of the temporal bone below and also to shorten the bone flap to provide for decompression later. In high pressure cases a ventricular tap is often needed before the dura is opened, either by a puncture through a small cut in the dura or through a specially placed burr hole. This may be on the same side, but at times it will have to be made over the ventricle of the opposite side, in which case the anterior puncture is the most convenient (*see* p. 1178). When ventriculograms have been made the same day, the ventricles should have been tapped afresh before the anæsthetic was given. When tension is judged to be sufficiently low, the dura is opened freely. If, after a tentative incision an inch or so long, the brain herniates so strongly through the opening that it disrupts, something is wrong. To continue the incision means that any part of the brain exposed by the continued opening of the dura will necrose. It needs some judgment and experience to know what to do next. A ventricular tap usually suffices to bring the pressure within manageable limits ; most relief comes when puncture reveals a cyst, the evacuation of which greatly reduces pressure. If not, help may be given by intravenous administration of 30 to 75 c.c. of 15 per cent. saline. If this also fails to improve conditions (and it may fail) the anæsthetic may be at fault, either through an obstructed airway or through too-brisk secretion of cerebro-spinal fluid. It will then be best to wait and open under local anæsthesia on the next or any succeeding day, for in the presence of very high pressure radical surgery is impossible. Modern methods of anæsthesia have reduced the frequency of these tense brains, which seem to be more often encountered by the inexperienced.

In the majority of cases the dura can be opened widely and fashioned in a flap with its base upwards towards the sagittal sinus.

It is a good practice to cut it through above as well, especially if it oozes much ; though this can be left until the close of the operation. Otherwise, a post-operative clot will be very likely to form because of oozing from it. Any meningeal vessels which bleed during the incision are secured with silver clips or the endotherm. The latter causes the dura to shrink considerably so that it becomes difficult to close if it is coagulated much. The remaining steps of the operation are directed at the pathological condition for which the operation is being performed.

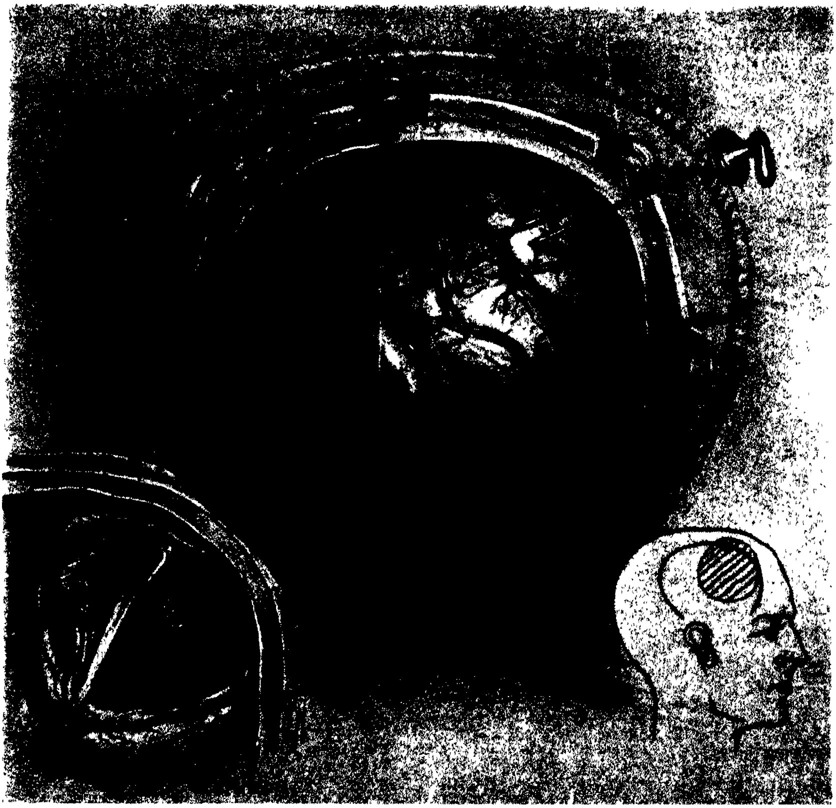


Fig. 574.—Cystic astrocytoma. Dissection of cyst, exposing the falx.

Recognition of the neoplasm.—Ordinarily the gyri are convex and well vascularised by very fine vessels in the pia. They are separated from one another by the fluid-containing sulci, in which arteries and veins are clearly recognizable ; the arteries in particular come to the surface for short distances, to disappear again. The vessels are misleading guides to cortical pattern, for they often cross the gyri. Pressure for a few moments with a large piece of lintine makes the cortical pattern more easily recognizable. Excessively wide sulci, firm convolutions, and subarachnoid lakes of cerebro-spinal fluid indicate local or general cortical atrophy. Opacities in the leptomeninges are often seen in such cases but are not often significant of the nature of the lesion. When, on the other hand, a tumour is present, the sulci become narrow lines because the widened gyri of the overlying brain tissue are pressed together ; when the tumour is close to the surface there may be a faint yellow colouration. Little, if any, cerebro-spinal fluid is to be seen, and the cortex looks pale though vessels are still clearly distinguishable ; the veins are dark. Sometimes the cortex feels soft over a tumour ; normally the gyri have a firm feel.

If the tumour presents on the surface its nature must be decided. If it is adherent to the dura it is most probably a meningioma, though it could more rarely be a secondary carcinoma or an old tuberculoma. Occasionally the malignant gliomas invade the dura, but they are much softer tumours edged by small tortuous pial vessels containing bright red blood. There is little difficulty in recognizing a meningioma, because of its hardness and well-defined margin sunk in the substance of the brain. Meningiomas can, however, be soft ; they are unmistakable because of their greyish-pink and circumscribed appearance, and the well-formed vessels to be seen on the buried surface when it comes into view as the tumour is being removed., The gliomas, when not presenting on the surface—and often they do not—lead to a characteristic widening of the gyri over them.

The presence of an underlying tumour is verified by introducing a brain cannula, which will reveal a resistance or change in texture, or enter a cyst. An estimate of the tumour's dimensions and of its point of nearest approach to the surface can be obtained by making a series of careful punctures a few centimetres apart. The plan will always be to remove the tumour by dissection with wet lintine pledgets, which find their way between the neoplasm and the surrounding normal brain tissue, until the tumour can be rolled or lifted out.

Uncapping a tumour and lobectomy.—It is often useful to uncover a subcortical lesion by removing a circle or oval of cortex from over it. This " uncapping " (Cushing) is carried out after securing the cortical vessels by under-running them with fine sutures, by clipping them, or by coagulation. Care must be taken to secure the vessels at the bottom of the sulci, otherwise the surgeon may be surprised by one of them. Not until the wound has been deepened to a greater depth than the bottom of the sulci does the excision become entirely bloodless, but as the tumour is reached a fresh but a different sort of vascularity is met ; a free bleeding from more primitive vessels. It is better to uncap a lesion than to expose it through an incision, because uncapping helps in decompression whereas incision alone may add to bulk by œdema developing in the contused lips. The surgeon may start with an incision alone, and then convert the cortical wound into an oval excision, 4 or 6 cm. long by 2.5 cm. wide, when the tumour has been found.

Uncapping is only a step towards something more radical. If a cyst is opened, a piece is cut out of the wall to allow of easier search for the tumour nubbin which has produced the cyst. This, large or small, must always be sought and removed. Should the cyst be one of the rare kind that seem to have perfectly innocent walls, a hole should be cut through the partition which separates it from the ventricle. (The ventricle can nearly always be recognized bulging into a cyst from which the contents have been withdrawn.) With a solid glioma, the amount removed depends on the nature of the tumour, as well as on its site. It is impossible to lay down any rules, except to say that as much tumour as possible should be taken out, considering the situation of the lesion, its vascularity, its definition, and the condition of the patient. This is done (*a*) by pledget dissection ; (*b*) by suction ; (*c*) by piecemeal removal with the punch forceps, or (*d*) with the electric endotherm loop. Frequently all these methods must be used. Suction is the quickest but it causes most blood loss and not all tumours are soft enough to be lifted thus. If the tumours cannot be dissected out entire, the safest and slowest method is the use of the punch forceps, especially when work is being done at a depth. The electric loop is admirable for avascular tumours such as the fibrillary astrocytomas and for gutting meningiomas.

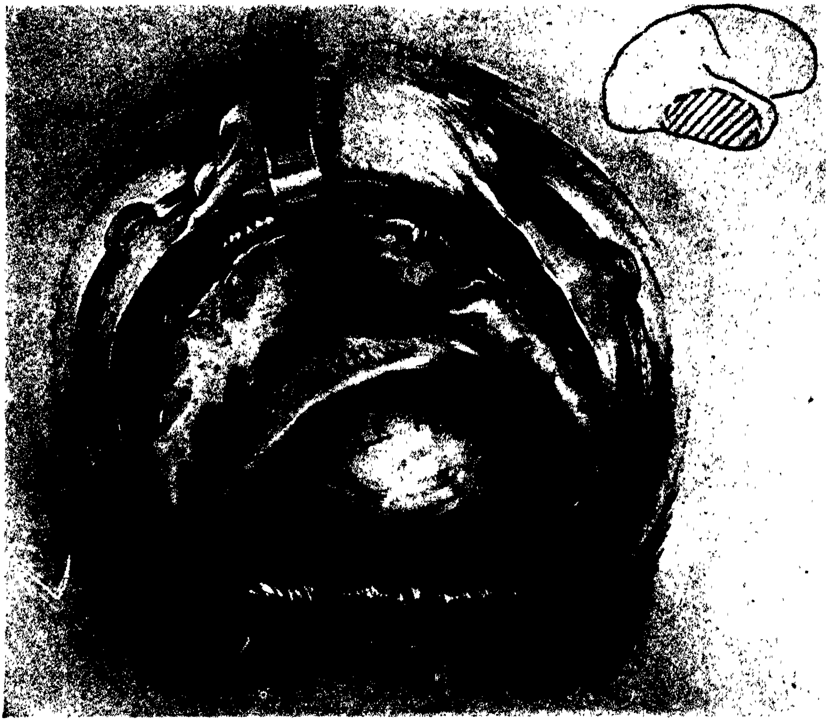


Fig.. 575.—Internal decompression by lobectomy. Right temporal lobe containing tumour excised.

Often the removal of a glioma is best performed by block-resection, that is, by lobectomy. Either of the frontal lobes can be removed without serious mental impairment, provided that the opposite frontal lobe and the rest of the brain is normal. The right temporal lobe may also be excised. (Fig. 575.) I have removed large portions of the left temporal lobe on several occasions without subsequent aphasia. The superior edge of the temporal excision should be a centimetre below the Sylvian fissure. Lobectomies give excellent results because the large dead spaces left behind (which fill partly with cerebro spinal fluid, partly by the expansion of the brain relieved of pressure) are most useful as regions of internal decompression. What is more, lobectomy most nearly approaches the surgical ideal of removing a tumour with a small margin of healthy tissue around it.

Control of hæmorrhage.—The best methods of controlling hæmorrhage from the brain during excision are : (*a*) silvr clips ; (*b*) electro-coagulation ; (*c*) muscle grafts. Silver clips of the McKenzie type are advisable. In applying them, it is best to make a minute cut in the leptomeninges at the side of the vessel, for the pia is sometimes tough. Electro-coagulation is excellent for veins. The larger the vein, the weaker should the current be. Arteries vary in their susceptibility to coagulation, depending on the amount of their adventitia and on the speed of blood-flow. It is often necessary to open up a sulcus deliberately in order to secure an artery. Bleeding from the dura is well managed by muscle grafts, taken either from the temporal muscle or from the leg. Thin pieces of muscle about an inch square are crushed by hammering and held on bleeding points. They can be more neatly used if they are stretched on gutta percha tissue, which protects them from being brushed off or accidentally sucked off. Muscle grafts adhere very firmly after a few minutes.

Closure of the dura.—The dura is usually closed at the end of a successful tumour extirpation, except below, where a decompression is left beneath the temporal muscle. (Fig. 576, a.) It is naturally very important to afford protection for the motor area if pressure is expected to continue (as after an unsuccessful operation). Otherwise a hemiplegia may be expected. It is equally a bad thing to leave a decompression of any size, or maybe at all, over a malignant glioma (glioblastoma multiforme), for it does no more than prolong a fatal illness. If closing the dura means severe compression of the brain it is best left open in whole or in part. The wise surgeon, therefore, only opens the dura in a high pressure case as much as the local condition calls for, and with foresight of the state of affairs when the operation is concluded. This entails considerable experience in neurosurgery and the ability so to recognize the nature of the lesion as to estimate how much he can do before he has gone too far. Moderate tension can be overcome by slitting the dura up the middle after suturing the edges back. Support is needed at the sides to allow proper settling and healing of the bone flap.

Can the bone flap be left with nothing between it and the brain? The answer is a qualified yes. A new endothelial covering certainly forms beneath the bone, but long before this develops there is great danger from cerebro-spinal fluid leakage and maybe from attrition of the cortex unless the bone surface is perfectly smooth and pressure low. A fascial graft from the thigh is excellent for closing large defects in the dura and is preferable to leaving a wide gap.

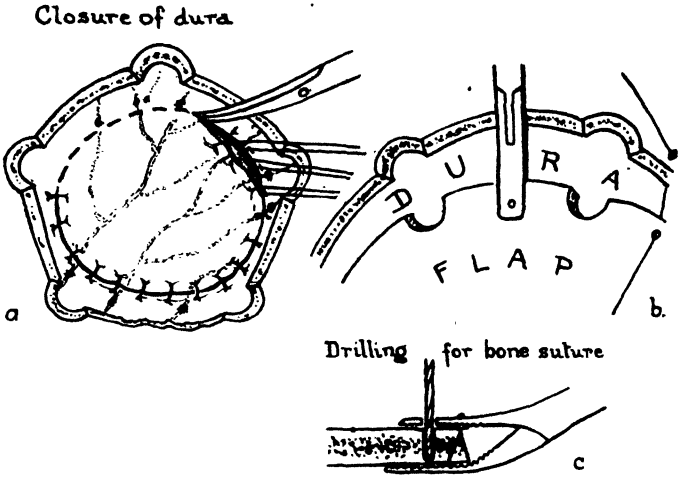


Fig. 576.—a, closure of dura which is finally cut all round to prevent post-operative bleeding.

b and c, drilling bone flap for suture (Adson's forceps).

Replacement of the bone flap.—The flap is carefully and accurately replaced; the bevelling of its cut edges prevents its falling in. Sometimes a drill hole or two may be made so as to fix the flap in position (Fig. 576, b), but this is unnecessary unless the exigencies of the case have called for the sacrifice of so much of it that it no longer fits accurately. Usually it is enough if the pericranium is pulled together in front, above, and behind with a few stitches, the number varying with the possibility of doing it neatly and comfortably without undue tension. A drainage tube, to remain for 24 or at most 48 hours, is sometimes placed beneath the bone flap at its lower and posterior end. The cut edges of the temporal muscle must always be most carefully sewn together as this is a potential source of late bleeding. Occasionally the surgeon is unable to replace the bone flap at all without severely compressing the brain. There is then no alternative to doing something that he greatly wishes not to do, viz. to sacrifice the bone flap. It has to be stripped off, leaving the temporal muscle and pericranium spread over the dura, and this helps to give a covering. The deficiency will lead to a most unsightly bulge if a growing tumour has been left behind, and probably to the long survival of a paralysed and helpless individual.

Closure of the scalp.—The suture of the scalp is always made in two layers. (Fig. 577.) Harvey Cushing often said that the suture in the galea (epicranial aponeurosis) was the most important step that he had introduced into neuro-surgery. This remark, which somewhat belittles his other achievements, is mentioned to emphasize that in some opinions the two-layer suture is vitally important. Certainly, an insecurely or carelessly sutured wound can lead to cerebro-spinal fluid leaks, cerebral fungus, infection and death, when more care would have obviated them. Fine black waxed silk (0 or 00) is used, the sutures placed at 1 cm. intervals. It is best to place a number before any are tied, as the strain on each individual tied strand is considerable when the scalp is everted for the next suture. Nor must many of the artery forceps be removed at once, or blood loss will follow ; the quantative importance of this has been mentioned. It can tip the scales against the patient in the last minutes of a possibly long and exhausting operation. The skin sutures are inserted with straight cutting needles, and Cushing's method of inserting 6 to 12 of these before any are tied is a neat and useful idea. (Fig. 577.) Finally, the wound is washed over with alcohol and silver foil or paraffin gauze applied.

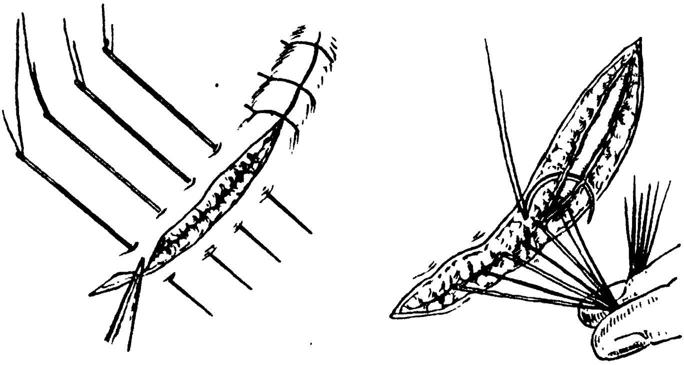


Fig. 577.—Two-layer closure of scalp.

The dressing.—The dressings can be reduced to a minimum, unless the wound has been drained, when a generous wool pack must be applied ; even that is inadequate to prevent staining. Fresh sterile wool should be applied outside the original dressings without disturbing them. For an undrained wound a few layers of gauze and then a sterile gauze roll wrapped snugly round the head is all the dressing needed.

After care.—The patient should be left on the table until there are signs of recovery of consciousness, especially after cerebellar operations on those in poor condition. I do not make this wait a routine step. Often enough the patient recovers consciousness almost immediately the nitrous oxide is stopped ; if not, the intratracheal tube is left in until there are signs of discomfort from it. After it has been removed, the patient must be watched for dyspnoea. A mouth tube may have to be introduced for a short time. Until consciousness returns, he should be kept semi-prone on his side to prevent the tongue falling back and to allow saliva to run freely from the mouth.

The patient should be nursed with the head raised as soon as his general condition will allow. The practice of nursing patients after brain operations flat, without pillows, is barbarous. It is extremely uncomfortable, leads to cerebral congestion and bleeding, and favours leakage of cerebro-spinal fluid. Three pillows is the correct height ; a bed that can be wound up to an inclined plane is best. If the patient has been dehydrated by vomiting, continuous subcutaneous saline can be given during the operation. This was a routine with cerebellar tumours in childhood, and could be usefully adopted for selected adults as well. The patients can soon drink, and there is no necessity to withhold fluids by mouth as is done after abdominal operations.

In my own clinic, nurses not only note down the pulse and respirations hourly, but every two to four hours they add the temperature and blood pressure, which they take themselves. They also write down the state of consciousness of the patient and record the amount of fluid drunk. In general surgery the exact hour of return to consciousness by the patient is unimportant, but in neuro-surgery it is vital. If it is not known there is no means of assessing whether a stuporose state is due to anæsthesia, basal narcotics, or blood-clot.

Under basal anæsthesia the patients are usually quiet for the first two or three hours. Later, if they become restless, small doses of morphine may be given, gr. $\frac{1}{6}$ being quite sufficient. It is best to err on the side of under-dosage. Patients with intracranial lesions are far more susceptible than others to morphia which, moreover, raises intracranial pressure. Chloral and bromide may be needed, or even paraldehyde, but only rarely is such medication called for. Drains, if any, are removed on the first post-operative day, and the sutures on the third day, unless there is much tension on the wound. Careful inspection must be made for collections of fluid under the skin ; these must always be let out by insertion of a ventricular needle through the wound edge, or by aspiration after puncture of the flap with a sharp needle. In some cases punctures will have to be repeated daily or every other day if sanious cerebro-spinal fluid is finding its way under the skin, a more likely happening when the skin flap has been dissected off the bone. Lumbar or ventricular puncture may be required when post-operative progress is not as smooth as it should be. Rises in temperature and pains in the neck and limbs indicate blood in the cerebro-spinal pathways, and call for punctures, usually lumbar. But there is no necessity to do routine punctures on patients who are making good progress. Ventricular punctures are not often needed except after some cerebellar tumours where it has been impossible to extirpate the tumour. As an exceptional measure a fine rubber tube may be left in the ventricle for a day or more and if the open end is carefully embedded in gauze wrung dry out of 1 in 20 carbolic dressings (Learmonth) infection rarely occurs.

COMPLICATIONS

(1) Post-operative Epidural Clot

This is the most frequent complication ; fear of it causes the neurosurgeon to spend time on his wound before he replaces the bone flap, time that appears excessive to the uninstructed onlooker. Thus, a wound which looks perfectly dry may still form a clot that necessitates early re-opening, and not until all the possible sources of bleeding known to the surgeon have been attended to can he rest content. The only surgeons who never see these clots are those who never look, or those who leave the intracranial tension higher than they found it. It is an early complication, for clot may form within six hours of the end of an operation; after 48 hours it is rarer. The source of the blood that forms the epidural clot is (*a*) the bone ; (*b*) the dura ; (*c*) the temporal muscle ; (*d*) most uncommonly, the tumour bed.

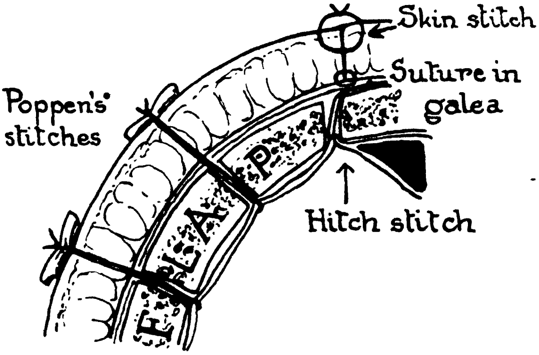


Fig. 578.—Hitch stitches, to hold dura against bone to prevent oozing.

(*a*) The bone is most likely to bleed in meningioma cases, where its vascularity has been greatly increased. This can be prevented by going over the inner bone surface with wax, but more particularly by stripping the bone off the temporal muscle until it is almost, but not quite, free. This is not always necessary ; it depends on the vascularity of the bone, of which the surgeon has opportunity to form an accurate opinion from the X-rays beforehand and from its behaviour during the operation. The bone edges are waxed over as soon as the flap is turned down.

(*b*) Hæmorrhage from the dura can be controlled by ensuring that the incision is carried round its exposed surface completely or almost completely, so that vascular communications towards the mid line are severed. Bleeding points mesially can be secured with silver clips. The " hitch " sutures described on p. 1197 are most useful in preventing post-operative venous oozing, and there has been a fall in clot incidence since their introduction. These clots are most likely to occur in the best cases, those in which so complete a tumour removal has been made that the dura tends to fall away from the skull ; or in those cases (such as pituitary tumours, diffuse angioma, or epileptics) where intracranial tension was never high. A further plan is to make fine drill holes at several points through the flap and to pass sutures from the dural surface to be tied on the exterior (Poppen—*see* Fig. 578). This obliterates the dead space between the dura and the bone and makes the formation of a clot almost impossible. If a downward slit is made through the dura beneath the temporal muscle to afford a decompression at the end of the operation, care must be taken to see that no bleeding has been started up from the posterior branch of the middle meningeal artery.

(*c*) Bleeding from the temporal muscle ought not to occur if the vessels have been properly secured. Infiltration of the muscle with novocain-adrenalin solution may temporarily produce dangerously avascular muscle. A very significant sign of clot formation is considerable swelling of the face or eyelids the day after operation. This does not always mean bleeding that will require re-opening of the wound, but it should put the observer on the alert. The really certain indications are increasing drowsiness or hemiparesis. Convulsions are less common, and unilateral pupillary dilatation is rare. It is much better to re-open the wound than to sit too long wondering whether to do it. The wound can be quite rapidly re-opened under local anæsthesia, the clot removed and such further steps in hæmostasis carried out as the local conditions demand. Usually, if the wound is re-opened soon, the prognosis is excellent.

(2) Post-operative Cerebral Œdema

Cerebral œdema can cause much the same picture as that of epidural clot. It is very likely to develop in cases where the dura has been widely opened and the tumour not removed, whether that tumour be a glioma or a meningioma. Its cause appears to be anoxia (*see* p. 1187). It is treated first by restricting water intake to 30 oz. in 24 hours, and by magnesium sulphate enemata, sometimes with lumbar puncture in addition. Intravenous glucose or, better, sucrose (50 per cent.) is sometimes given. In its worst form œdema causes hyperthermia and death. It seems to come on very rapidly, does great damage and then very slowly subsides. It is doubtfully wise, in the present state of our knowledge, to force fluids on brain tumour patients ; hence, subcutaneous saline can only safely be given if the patient is dehydrated. The only proper substance for intravenous administration is blood or plasma.

(3) Cerebro-spinal Fluid Leakage

This sometimes occurs even after the most careful closures, but the surgeon should always feel it as a reproach. It is most apt to occur when wounds are not early enough or carefully enough inspected after operation. Dressings with dry carbolized gauze are the proper applications or, if there is any sign of gaping of the wound edges, fresh sutures should be inserted. Otherwise the leak may develop into a cerebral fungus, once the bugbear of neuro-surgery.

(4) INFECTION

Now and again infection creeps into the most impeccable technique. Nothing seems harder than to trace a wound infection to its source, but most often it comes from the mouths or throats of those around the table. All visitors, as well as those engaged in the operation, must be furnished with masks impervious to droplet-penetration, of which the best is the cellophane type. It is now recognized that the incidence of infection rises with the duration of the operation, the number of persons in the theatre, and the amount of movement (Cairns). Individuals moving about rapidly disturb the atmosphere and lead to an increase in the number of colonies culturable on agar plates exposed for test near the wound. Clots are the next most dangerous potential centres of sepsis. Infection rarely occurs in the snug wound ; those leaving a dead space—intra-ventricular operations, lobectomies, posterior fossa explorations—are most liable. Slight morbidity in the wound edges is a flaw but is not dangerous unless the wound is to be re-opened for a second stage, a step which the mildest infection forbids. The utmost care must therefore be taken in all intracranial operations to obtain perfect healing ; hence the use of inner drapings wet with perchloride, the careful shutting-off of the wound and sewing the drapes to the skin so that they cannot slip during what may be a long session, and gentleness in handling tissues. The virtue of the true osteoplastic flap in minimising the risk of infection has been noted.

The treatment of infection follows general surgical principles. Imperfect wound healing may be due to the long-continued compression of the scalp edge by the weight of the artery forceps. This can be prevented by carefully packing gauze strips under the forceps to increase their pull on the galea without pressure on the skin. It has fallen to most surgeons to remove a bone flap because of necrosis of its edges. There is no need for hurry in the decision to do this, always a most repugnant step, and fortunately only rarely necessary. A disadvantage of neuro-surgical operations is that many of them last so long and require such big teams. Re-design of the ventilation of theatres and introduction of air-conditioning are needed. Meanwhile I have had considerable success from insufflating the wound surfaces with 5 gm. of sulphapyridine.

THE DIFFERENT TYPES OF TUMOUR

MALIGNANT GLIOMAS

Although I have advised that no malignant tumour should be attacked unless there are special reasons for thinking that it can be completely removed, it is proper to add that this is a counsel of perfection. Experience certainly helps greatly in the pre-operative detection of tumour types. At times a surgeon may find himself committed on a clearly hopeless case to steps much more lengthy and ambitious than he approves. The abdominal specialist does not have to face this problem. When an abdomen filled with malignant metastasis is opened it can be immediately and rapidly closed and the case is unaltered. But when a malignant brain tumour is laid bare such swelling may occur as to necessitate the removal of a great deal of the growth before the bone flap can be replaced. The surgeon who says that in such a case nothing should be done is talking theoretical sense, but practical nonsense. For either the bone must be peeled out and the dura left widely open, when a huge protrusion will develop and the patient's crippled life be preserved long after his usefulness is over. Or else the bone flap must be forced back, when he will surely die within a few hours. A well-planned excision of the tumour will obviate both these difficulties; experience proves that the post-operative mortality of excision is lower than that of decompression and occasionally these patients are able to lead useful lives for a time, and then die after a relatively short terminal illness. Internal rather than external decompression is the ideal at which to aim.

Parasagittal Meningiomas

A tumour that calls for special comment is the meningioma ("dural endothelioma" of older writers). The apparent origin of many of these tumours from the arachnoidal villi means that they appear in the immediate neighbourhood of dural sinuses (especially the parasagittal lacunæ) into which these villi project. The sites of election are now well known (*e.g.*, parasagittal, olfactory groove, dural convexity, sphenoidal wing, tuberculum sellæ, falx, tentorium, petrosal sinuses, clivus).

Pre-operative care.—This includes not only routine examination of the patient, but also very careful study of the radiographs to ascertain the degree to which abnormal vessels in the diploë can be recognised. The surgeon knows that if the tumour is a meningioma he is going to face hæmorrhage, and he must be prepared to combat it and compensate for it. It will be necessary, therefore, to observe whether there is any region of special vascularity that may call for slight variation in the routine making of the osteoplastic flap. It will be necessary also to provide blood donors. So important indeed are the latter that it is wise never to begin an operation on a meningioma without 600 c.c. of blood ready at hand. In exceptional cases it will be wise to have two or three other donors, either in the hospital or on very short call.* Hence the statement I have often made: that the first incision in a meningioma case should be at the ankle, to uncover a suitable vein. In all intracranial operations it is more convenient to use a vein in the leg for transfusion rather than in the arm. At the same time a piece of muscle can be taken higher up from the anterior compartment of the leg, or from the inner edge of the sural group, to use as Horsley grafts to bleeding points on the sinus or its lacunæ laterales.

Where there is no discernible alteration in the vascularity of the skull or meninges, it may not be necessary to carry precautions quite so far. But experience teaches that it is much better to be properly armed beforehand than to have to improvise reconstructive aids under duress. In any case in which considerable bleeding is anticipated, it is most important that the air-way should be completely unobstructed ; another important thing is to raise the patient's head. It is possible with a suitable head-rest so to place the head that it is postured almost as if the patient were sitting up. Should occasion demand, the tilt can be altered. It is often difficult to transfuse by the gravity method a patient so inclined ; care must be taken therefore to see that the intravenous cannula is of a type to which a syringe can be fitted.

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*The recent availability of plasma and stored blood in quantity, and on the shortest notice, already gives this advice an old-fashioned air.

Shall the operation be concluded in one single stage or in more ? This question has already been touched upon as a generalization (p. 1188). If there is exceptional vascularity in the radiographs this decision can be left until the bone flap has been cut. On occasion, the hæmorrhage encountered may be far in excess of anything anticipated, so that the surgeon is compelled to break off his operation. This is best done before the dura is opened (unless ventriculograms have just been made), or after the dura has been divided around the edge of the tumour. But if the dura is opened and the tumour not removed, severe cerebral œdema is very likely. There is rarely extreme urgency in meningioma cases and, even if the operation is done in stages, there is no need for much delay. The remaining part may be done in a few hours or a few days.

The incision.—In dealing with a parasagittal meningioma it is always essential that the superior longitudinal sinus should be uncovered. The bone removal must, therefore, transgress the midline. (Fig. 579, a.) The point is whether it is a good plan to make the flap primarily to cross the midline or to go almost up to the midline and then to uncover the sinus by nibbling further bone away. I much prefer the latter method, the only disadvantage being that a small gap is left where the bone has been removed. On the other hand, the sudden uncovering of a length of the sagittal sinus when a bone flap is raised from over it may lead to furious hæmorrhage, though it does not always do so ; and the anterior third of the sinus can safely be uncovered by the primary flap. Since the surgeon cannot tell what will happen, it is safer to use the more cautious method. The incision is made in the usual way but with special care to prevent blood loss ; the advantages of a true osteoplastic flap for meningioma have been mentioned. There may be considerable bleeding from the bone when the burr-holes and saw cuts are made, and bone wax must be freely used, even if the waxed point in the bone has to be removed shortly afterwards. Characteristic of the meningiomas is unusual bleeding when the pericranium is exposed and reflected from the bone to make a pathway for the saw cuts. Bone wax must be rubbed on the bone ; probably speed in making the flap is the most valuable asset. But there must be no hurry, for the top arc of the bone flap needs making most carefully, especially where it nears the sinus.

Adhesions and the irregularities caused by parasagittal pits in the bone, pits occupied by venous lacunæ, make it difficult to separate the dura. The way to overcome this is to sink an extra burr-hole or so. If the dura, even then, with very short distances between each hole, cannot be safely separated, the holes should be joined by nibbling with Wilm's forceps. An advantage of this method is that it leaves a wide enough gutter for bone wax to be inserted, a difficult matter through the narrow line of the saw cut. When the flap is completed, the surgeon must weigh the case up again by reference to the blood pressure chart. It is at this point that a transfusion may have to be given, that is, before the flap is elevated. If blood has to be given at this stage it is almost certain that more will be needed later.

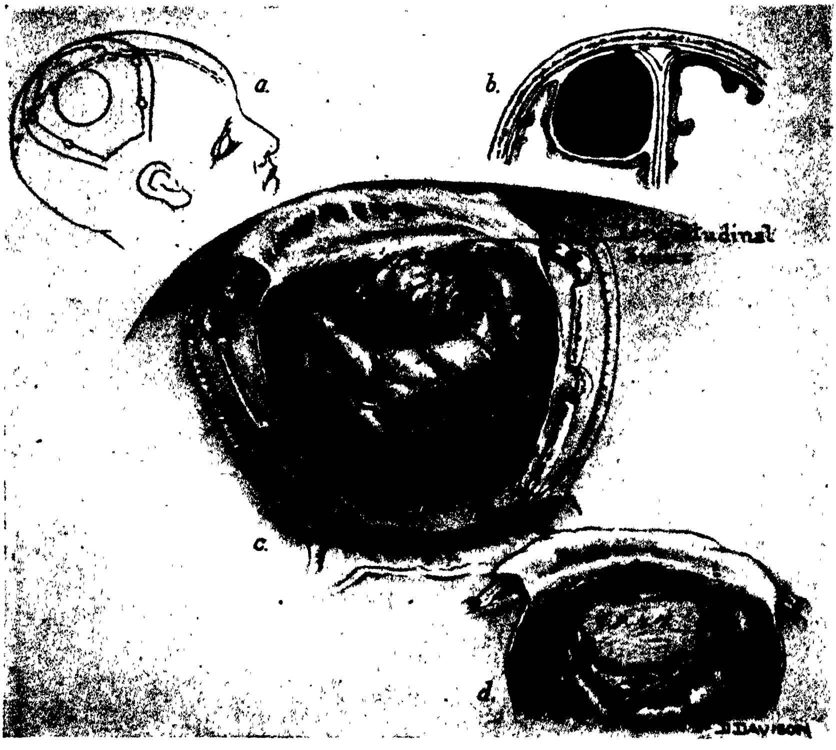


Fig. 579.—Parasagittal meningioma, the common, largely buried type.
a, Skin and bone incision crossing midline. b, schematic cross section. c, the undisturbed tumour. d, tumour bed after removal.

A decision to continue having been arrived at, the bone flap is broken down and squares of wet lintine (6 x 3 cm.) are instantly placed over the sinus and held there. They must not be pressed on too hard or the sinus is pressed away from the bone and may bleed from fresh and inaccessible places. When the bleeding has stopped, the lintine is replaced by muscle grafts, over which first sterilized guttapercha tissue and then lintine again is laid. The rubber prevents the lintine from sticking to the grafts. It is best to do this before the dura is opened, for the replacement of the one by the other may cause such bleeding as to destroy the circulatory balance once more. More bone must now be removed medially to expose the sagittal sinus opposite the attachment of the tumour. A small extra skin incision (making it a "split-ring") may have to be added to allow this. (Fig. 571e.) The middle meningeal artery and its branches are coagulated as early as possible, and the inner surface of the bone flap waxed over and considerably stripped from the muscle to stop oozing. All bleeding having been arrested, the wound is closed off by fastening green towels to the wound margins with Michel clips.

The dura is now opened, not in its whole extent but close around the outer edge of the tumour which can, as a rule, be seen or felt. This will take some time to do because the dura is always very vascular and requires coagulating, or the application of silver clips at many points. Once the dura has been incised around the tumour the most anxious moments are over and the remainder of the operation can be carried out with ease. (Fig. 579.)

The extent to which the tumour is attached along the midline varies; sometimes it may be only for a centimetre, more often for 3 or 4 cm. Another important variable is the consistency of the tumour itself; this depends on its histological structure. The easiest are the hard, smooth, fibroblastic type; the most difficult the soft, lobulated, meningothelial type, and the angioblastic.

The method of removal depends on the toughness of the tumour and the ease or difficulty with which it can be detached along the midline. When its attachment is narrow and the tumour hard, it is easiest first to free the tumour around its outer circumference, and then, elevating it from its bed, to tilt it across the midline. Its pedicle can easily be cut through after coagulation. If the sinus bleeds, the edges must be closed with mosquito-forceps. Two or three fine silk sutures will close small gaps in the wall; they can be made more secure by covering them with muscle grafts. If the tumour is very large its elevation must damage cerebral tissue, for the greatest width of the tumour is frequently buried. It helps to minimize cerebral trauma if the tumour is "gutted" (reduced in size by the electric loop), before any attempt is made to extricate it. An exceptionally vascular tumour should be desiccated by bipolar diathermy before its interior is scalloped out. But since recurrence of meningiomas is certainly due to seeding, the broken tumour surface must be well endothermized to kill potential transplants. A large tumour may, by this method, be elevated without causing as much cortical damage as it would otherwise do. Where there is a wide attachment of the tumour to the sagittal sinus, the tumour cannot be safely swung up on its pedicle. The attachments to the midline must be divided as the tumour lies *in situ*. This is most easily done by free use of the blunt hook and the diathermy applied to its handle. (Fig. 580.) The tumour, once freed along the midline, can be gently pulled up by sutures inserted in it, wet lintine pledgets being used to sweep brain tissue off it and to line the bed temporarily. All vessels crossing from the cortex are obliterated by diathermy and cut, first the large superficial veins beneath the arachnoid, later those deeper placed vessels crossing in the tumour bed.

The final connections of the tumour having been carefully divided, the tumour is lifted out and the jugulars are compressed by the anæsthetist to induce venous bleeding so that any unnoticed potential source of hæmorrhage may be secured. Muscle grafts are laid along the sinus and the wound filled with Ringer's solution. If part of the bone flap has been invaded by tumour, this part is best cut away with bone forceps. An alternative method is to diathermize it heavily whilst a finger on the outer side, judging rise of temperature, protects the scalp from undue heating. The flap may be removed, boiled in saline, and replaced. I have done this but it is not an invariably safe plan. The defect in the dura should be repaired at once by a fascial graft for there is commonly considerable loss of dura in meningioma removals since the whole area of attachment must be sacrificed. A few hitch-stitches are placed and the bone flap replaced with a drain leading out from behind it. Care must be taken not to lose blood from the scalp when it is sutured, because blood is being badly needed by the patient at this stage. It is possible to remove most parasagittal

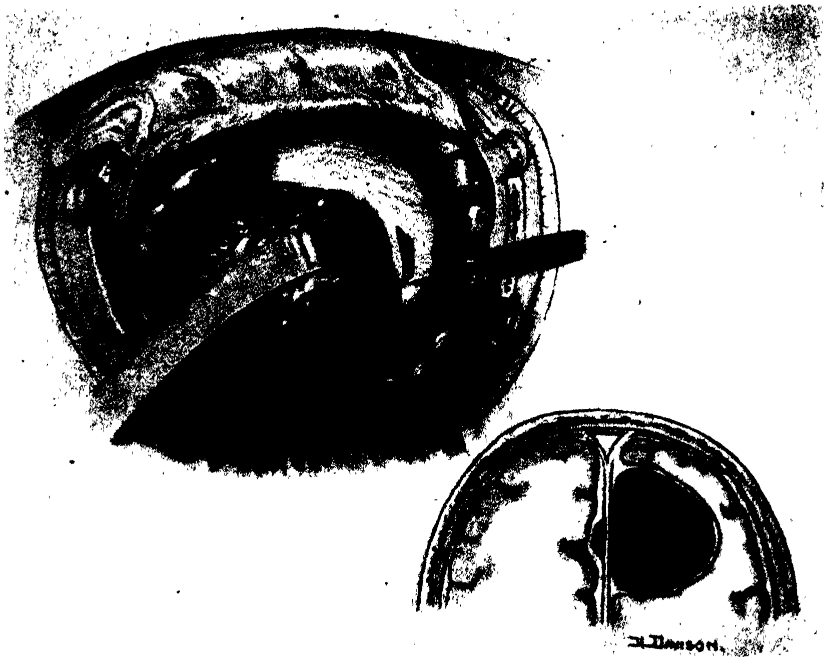


Fig. 580.—Meningioma of falx. Observe tumour local invasion sprouting through falx, a button of which must be removed.

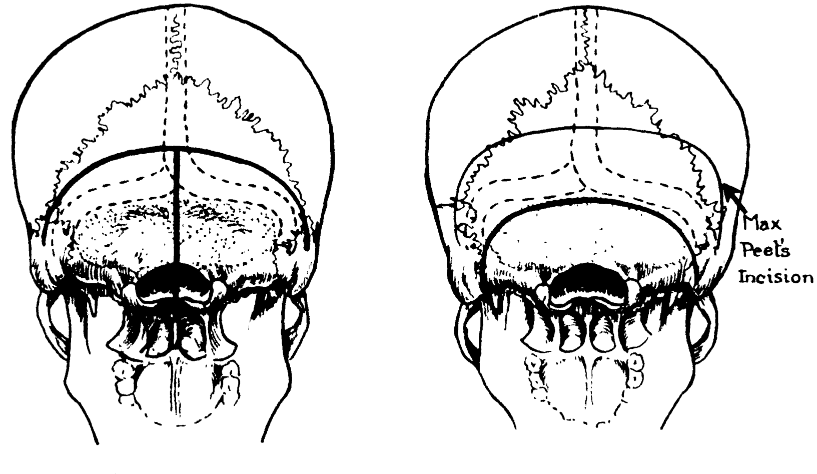
meningiomas fairly quickly and relatively easily if they are set on methodically. Some can be very difficult. The meningiomas of the convexity are much easier, for they do not have to be dissected off the sagittal sinus. In that case the only concern arises from bleeding during the actual exposure of the tumour rather than during its elevation.

Meningiomas of the Cranial Base

The general principles are the same but there are special difficulties because the attachment of the tumour to the dura is reached last instead of first. Further, all these tumours are buried beneath the brain, which cannot be elevated if pressure is high, so that various types of excision of a frontal or a temporal lobe must be the first step. These tumours present the most formidable problems in the whole range of the surgery of benign or quasi-benign neoplasms. The reader is referred to special monographs for detailed operative description.

THE CEREBELLAR APPROACH

The original unilateral approach was bad for all posterior fossa tumours except the acoustic neurinomas, partly because it did not allow a sufficiently free exposure, but especially because it did not provide relief for tonsillar herniation. The need for decompression of the medullary centres caused Harvey Cushing to introduce the cross-bow incision (*see* Fig. 581, a). The vertical limb made it easy to remove the arch of the atlas, and the lamina of the axis, too, if need be, whilst the transverse part of the incision was carried so widely to the sides that a very full and free exploration not only of the vermis but also of the cerebellar hemispheres was possible. The great disadvantage of this incision is the time necessary, not to make it, but



a Cushing's Cross-bow incision b. Traditional

Fig. 581.—Cerebellar incisions.

to close it, so that it has generally been superseded by a plain transverse incision, representing the horizontal part of the crossbow. Equally, the vertical part alone can be used, but it is more useful for children, in whom a midline lesion is probable. Special incisions are necessary for posterior fossa operations requiring good exposure of the cerebello-pontine angle, and will be described in their proper places (e.g., for acoustic neuromas, trigeminal root section).

The classical crossbow incision entailed an incision across the occiput 2 cm. or so above the cranial attachment of the nuchal muscles. These were cut across just sufficiently below their attachment to leave a fringe for suture at the close. This is the modern cerebellar incision. It is rather easier to dissect the flap down so as to uncover the atlas if the incision crosses below the inion instead of above it, but a good deal depends on the shape of the occiput, and the low transverse incision is most useful in patients who have a shallow posterior fossa and an unusually prominent external occipital protuberance. Another incision again is a higher one still, in which the muscles are not cut at all but are taken down in a musculo-aponeurotic sheet (Peet, Fig. 581, b).

The preparation of the patient and the anæsthetic are as before, save that endotracheal avertin-gas anæsthesia, except in grave emergencies, is a routine for these operations. They are bad to do under local anæsthesia, for the position is a very trying one for the patient, and the muscles are difficult to re-suture. Also, if the subject has been heavily dosed beforehand, his breathing will very likely become obstructed, requiring an intratracheal tube. I believe that it is best to decide on general anæsthesia as a routine, for anæsthetic amendments are harder to make in the course of cerebellar than in any other neurological operation.

Posture for cerebellar operations.—The patient lies face downwards with the head supported in a horse-shoe head-rest of adjustable height. It should be of a type allowing flexion and extension of the head by altering the angle of the head-rest with its support, and allowing also of rotation to either side for work in the cerebello-pontine angle. Ordinarily, the ideal is to have the head flexed just sufficiently to make the sub-occipital region as accessible as possible and to put the nuchal muscles mildly on the stretch. Overflexion of the head on the neck leads to congestion. At the close of the operation it will be necessary to reduce the flexion so as to relax the muscles for approximation by suture. The patient's shoulders must be supported in Cushing's shoulder rests, but even this is not sufficient to give freedom to the chest and abdomen for easy breathing. A sand-bag should be placed under the pubes to lift the abdomen sufficiently for free respiration. The table itself must be very well padded ; the usual sorbo mat is not thick enough. A special mattress or pillows are better. If the surgeon tries the position himself he will soon learn the little tricks necessary for reasonable comfort during a long operation.

The operation.—The first step in the operation used to be the puncture of a lateral ventricle, but, as Cushing, who introduced it in 1909, pointed out later, it has the disadvantage of causing such a lowering of pressure that the structures in the posterior fossa fall back into normal station so that even a largish tumour, if it is deeply placed, may escape recognition. For that reason it is better not to make the puncture unless there is good reason, i.e., congestion and severe venous oozing (occasional) or unless the dura is too tight to be safely opened (rare). Ventricular puncture is simple when a cerebellar tumour is present because the ventricles are enlarged, but, since the patient lies face downwards with the head slightly flexed, the operator must take care not to lose orientation. It is therefore wise, before the drapes have been placed, to mark with iodine not only the site of the burr-hole proposed for the ventricular puncture, but also to draw a line running towards the glabella. After the ventricle has been found and the cannula introduced, the ventricles are decompressed slowly, to diminish venous engorgement and aid respiration.

Incision.—The skin incision crosses from mastoid to mastoid immediately above (more rarely below) the external occipital protuberance, and when it reaches the mastoid processes it curves downwards to end about the level of the mastoid tips, just at the hair-line. The incision is made with the usual precautions against blood-loss. The occipital arteries can be picked up and tied separately. When all artery forceps on the galea have been neatly bundled, the lower edge of the incision is dissected down until a clean incision can be made with the endothermy cutting current through the muscles directly down on to the occipital bone for the whole length of the wound. By the same means, aided by a sharp rougine, the muscles are separated downwards in one unbroken sheet to the foramen magnum and far out to the sides. Skin and muscle in one flap, its thickness depending on the muscularity of the neck, are retracted inferiorly till as much as can feasibly be bared of the squamous portions of the occipital bone is in view. This dissection can be elegantly done with the cutting current, keeping dead on the bone. In children the separation is remarkably easy ; in the muscular adult it is more difficult, for tendinous slips arise from well-marked ridges and pits in the bone. The operation is always difficult in a patient whose occiput shelves forwards very sharply, easiest in those in whom it makes a nicely rounded bulge. Wax always has to be used to block up the emergent veins from the diploë, especially in long-standing high-pressure cases. The muscles are fully dissected down, first to the foramen magnum, and then beyond it, in the midline only, in order to allow laminectomy of the atlas. (Removal of the atlantal posterior arch is to all intents and purposes part of the routine of any cerebellar exploration and decompression—so common is tonsillar herniation.) The tissues are readily and bloodlessly dissected bluntly off the occipito-atlantal ligament and then the atlas is cut down upon. Considerable retraction is needed to bring it in view, and sometimes a short (4–5 cm.) vertical incision must be made, converting the approach into a crossbow. The arch is cleared and 3 cm. of it nibbled away, either now or after the occipital bone has been removed.

Next, a drill-hole is made on each side of the midline of the squamous occiput and the bone widely removed; this is sometimes very easy, for it may be paper-thin. There is risk of the drill " plunging," so that the holes are best made in the thicker bone just below the transverse sinus. A very free bone removal should be made, including the margin of the foramen magnum, laterally out to the mastoids and superiorly to the transverse sinuses. The full exposure of the sinus of one side for lateral recess operations is described later. The bone bleeds most in the midline below the torcular, but oozing is easily checked with wax; blood may come from the exposed dura oozing down from above (stopped by tucking a muscle graft up under the bone edge), or from the inferior occipital sinus (stilled by coagulation). The surgeon must beware of injuring the posterior condyloid veins; the mastoid emissaries are only endangered when a very wide exposure is made. The wound should now be dry, and until it is, the next stage must not be embarked upon. Fresh towels are clipped to the wound edges and then the dura is opened.

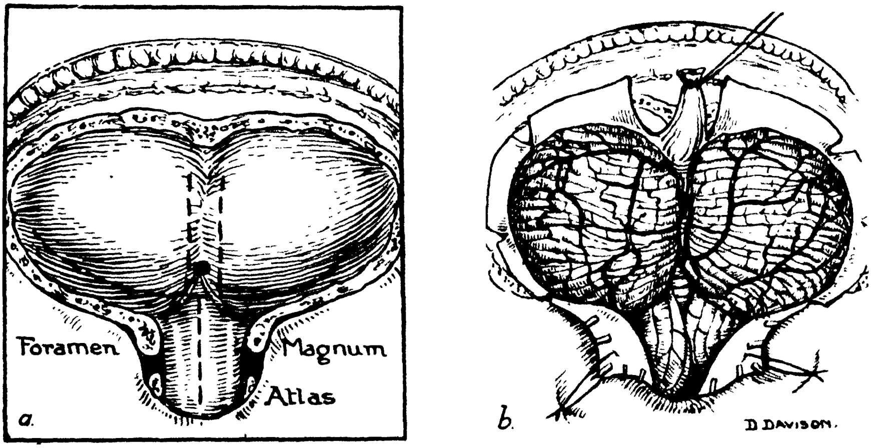


Fig. 582.—Dural incisions. In (a) the black dots indicate points for diathermy coagulation. In (b) there is tonsillar herniation; enlarged left tonsil indicates left sided tumour.

Dural incision.—A small incision is made over the left cerebellar lobe and a narrow piece of lintine pushed underneath to protect the cerebellar cortex from being cut by the side of the scissors blade. The dura is opened by an incision that curves downwards and crosses the mid-line about 1 cm. above the level of the foramen magnum (*see* Fig. 582). The inferior occipital sinus is divided in the course of this sweep, but it is easily controlled by electro-coagulation beforehand or by applying silver clips. Finally, this sinus is turned upwards out of harm's way and fixed so that it cannot bleed again.

The dural incision is now carried down vertically in the midline through the occipito-atlantal membrane and onwards through that part exposed by the removal of the arch of the atlas. Three or four silver clips will have to be pressed on to the cut edges here. The surgeon can often tidy up his wound and prevent hæmorrhage from the region where bone and dura meet round the inferior rim of the occipital bone defect by sewing the cut edge of the dura to the muscle at two or three places on either side. It is wise not to open the cisterna magna widely unless it is needful to do so, *e.g.*, for a full inspection of the fourth ventricle, or for splitting the vermis. Puncture of the cistern with the pointed tenotome allows all the fluid to escape without having opened it up so fully that blood can enter the cerebro-spinal fluid spaces and cause a more stormy convalescence.

The description which follows is of the exploration of the posterior fossa when it is certain that the lesion is not in the cerebello-pontine angle. It is true that there may be doubts. If so, bone must be removed far laterally, because the angle cannot be safely or adequately explored through an exposure that would suffice for a mid-line cerebellar glioma. The special approach to the angle, so far as it calls for modifications, is described on p. 1223.

Abnormal appearances.—The next step depends on the anatomical picture displayed. If a tumour can be seen altering the cortex of a cerebellar lobe or even projecting through it, the search is over as soon as begun. If not, there may be local enlargement of cortical vessels, indicating the presence of an underlying angioblastoma, widening of the cerebellar folia of one side, or of the vermis or, again, a tongue of tumour may extend from the fourth ventricle down over the dorsal surface of the medulla, as happens with ependymomas. Small greyish opacities on the cerebellar cortex suggest secondary deposits from a medulloblastoma. If nothing so obvious is seen, attention is directed to the vermis. Is it sunken ? Is it hidden altogether ? Is the volume of one cerebellar lobe clearly greater than the other, causing the vermis to be curved laterally ? Further, a very important observation is made concerning the size and symmetry of the cerebellar tonsils, which are prolapsed when cerebellar tumours are present, sometimes as low as the axis. If one is unmistakably thicker and longer than the other, there is certainly a tumour in the lobe of that side. With a ventricular cannula gently and carefully inserted, search is made for a definite resistance indicating the presence of a subcortical glioma or, alternatively, the wall of a cyst.

If there is no abnormality save perhaps a slight generalized enhancement of cerebellar mass and considerable tonsillar herniation, what should be done next ? The first thing is to open the arachnoid of the cisterna magna by hooking it up and incising it with fine scissors. Cerebro-spinal fluid then escapes freely and the tonsils can be seen in detail. If they show no pathological asymmetry they are very carefully separated from one another with narrow brain retractors, and the foramen of Magendie sought. Through this a good view can be obtained into the fourth ventricle and an ependymoma or choroid papilloma, if present, will be seen. The ease with which the foramen can be brought into view varies. Usually the tonsils are stuck down to the closed part of the medulla and gently laced there by fine arachnoidal bands. Gentle dissection will allow them to separate sufficiently for the calamus scriptorius and the posterior inferior cerebellar arteries to be well seen. A fine catheter may be passed into the fourth ventricle and along the iter into the third ventricle. This ensures that there is no gross block by tumour or verifies the presence of a stricture of the iter. If no tumour has been discovered in the search outlined, and usually it will have been found, it is clear that the lesion is deeply placed; probably it is in the superior vermis. This is especially probable in children, who are so apt to develop medulloblastomas which invade any part of the vermis without its presence causing the median prominence that would theoretically be expected. The actual removal of the tumour is carried out by the methods of dissection described on p. 1200. The cerebellar astrocytoma is the most benign of all gliomas and is well demarcated by appearance and texture from its surroundings. (Fig. 583.) It may be vascular and very difficult to remove when large, solid, and high under the tentorium.* The exact steps to be taken vary a little with every case and can only be learned by experience. The cysts are the easiest. Puncture alone is not enough; the tumour causing the cyst must be found and removed. Cerebellar cysts are never degenerative, but are caused by active transudation alongside the growing point, not into it. Most deep tumours are best approached by splitting the vermis from below upwards, after securing the surface vessels. If, even after puncture of the lateral lobes and splitting the vermis, no tumour can be found, the wound must be closed but the case kept under periodic observation with the intention of re-exploration should there be symptomatic recurrence.

Closure of the wound.—When the operation is completed and every bleeding point has been secured, the wound is closed by suturing the musculo-aponeurotic flap carefully back to the fringe of muscles below the superior nuchal line. This is generally very easily done; it is helped by slightly extending the head. The waxed silk sutures, tied three times, are placed 1 cm. apart and, when they are all in, the surgeon should go over the line again looking for opportunities to place more. The scalp is closed in a further two layers as usual. The lateral ventricular cannula is taken out and the wound through which it was introduced closed.

As a final measure, after the first dressings have been put on, it is a help to carry a strip of elastoplast from the top of the shaven head to the back between the shoulders to relieve the muscles of the neck from strain.

Cerebellar tumours are very interesting technical problems and, on the whole, they are quite as good risks as hemispheral growths, although they ought to be much more formidable because of the proximity of the primitive vital centres in the brain stem. Removal

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* Those who require further details of the technique of removal should consult Harvey Cushing's paper, "The Cerebellar Astrocytomas," *Surg. Gyn. Obst.* 1931, lii, 129.

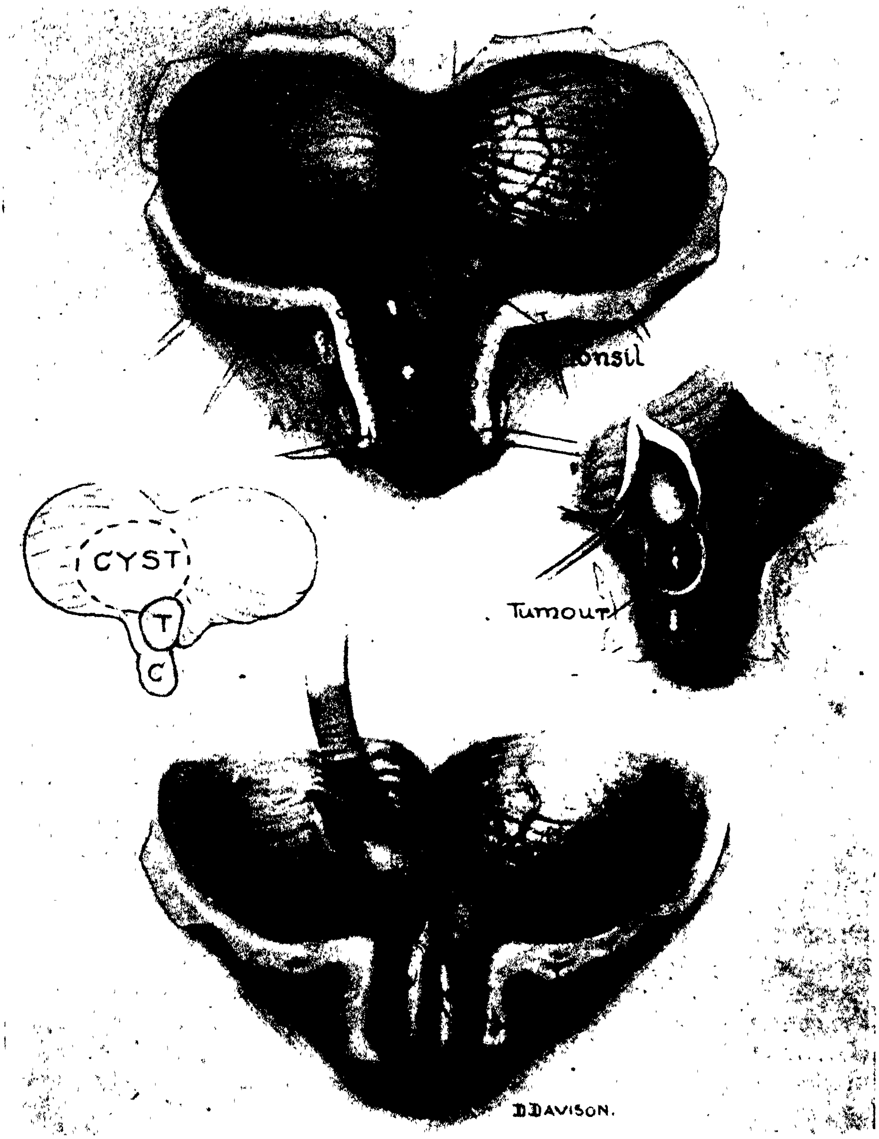

Fig. 583.—Cystic astrocytoma involving cerebellar tonsil which is excised.

of the arch of the atlas greatly facilitates the recovery of medullary function and adds greatly to the patient's comfort during the immediate post-operative period.

After-care.—It is a good practice to leave the cerebellar case face downward on the shoulder-rests until he begins to move. This was Cushing's practice. Return to consciousness is usually very quick after the nitrous oxide is stopped. It is well to leave the intratracheal tube in place until the patient is definitely waking up ; he is then taken off the table and placed in bed with the head elevated. Care is taken with the first sips of water, for he may have difficulty in swallowing, though this is unlikely except with acoustic neurinomas. The only other special point is that lumbar puncture will probably be needed from the second day on. The indications are pain in the back and limbs (indicating gravitation of blood down the theca) and pyrexia. I am no believer in routine daily lumbar punctures ; they are unnecessary and upset the patient. But when headache is bad and there is considerable physical discomfort, punctures should be made and repeated as long as they are doing good service. Ventricular taps are rarely needed, and usually are only done if a patient is sinking into coma or generally doing badly. It needs some judgment to know when to perform the punctures, but the rules are founded on knowledge of the physiological activities of the hypothalamus, the brain stem, the cerebro-spinal fluid, and the effects that the tumour or its removal has had on them. De Martel and Learmonth advocated drainage of the ventricles after operation by leaving a cannula in or by replacing it with a short length of sterile ureteric catheter (*see* p. 1204). I have found this helpful only when the tumour could not be removed.

Variation in the cerebellar incision.—The exact relationship of the incision to the external occipital protuberance depends on the shape of the skull and the muscularity of the neck. It is not easy to expose the atlas properly if the incision is made well above the protuberance on a thick-necked individual. To render this easier the incision is curved down at either side, where the occipital artery may be met again as it emerges from its transit deep to the mastoid process. The straight, vertical mid-line incision commends itself as an approach giving easy access to the vermis, but it does not permit wide access to the sides. I have often used it with the modification of undercutting the skin sufficiently to allow a short transverse division of the muscles on either side. I have also used the alternative transverse incision 3 cm. above the protuberance, cutting the pericranium across, rongeuring it down, and taking it and the muscles off the bone with the cutting endotherm in a continuous unbroken sheet (Peet). Closure is obtained by careful closure of the aponeurosis. The chief variations needed are for the acoustic neuromas and section of the fifth and eighth and ninth nerves in the posterior fossa (*q.v.*).

ACOUSTIC NEUROMAS

The problem of the acoustic neurinoma is different, for here the approach must be a lateral one and it must secure free access to the posterior surface of one petrous bone. This can be achieved by the ordinary, full-length, curved, transverse incision carried outwards very thoroughly on the side on which the neurinoma lies. It is but a slight modification to use only the appropriate half of this approach but, because of the need for relieving tonsillar herniation at the same time, this is only for the experts (and surely no others would attempt these difficult tumours). The steps of the operation, briefly told, are as follows.

The edge of the lateral sinus having been made visible above, by judicious undercutting of the bone beneath the muscles, and the dura having been opened from the posterior edge of the mastoid process across the midline, the cerebellum is gently retracted. The tumour, or a cyst covering it, comes into view (Fig. 584) ; it is embedded in the anterior surface of the cerebellum and is closely applied to the pons Varolii. When a cyst is present, the exposure is easier because once it has been tapped the cerebellum becomes more mobile and more of the tumour can be quickly seen. The tumour is next " uncapped " by the removal of rather more than one-third of the lateral cerebellar lobe overlying it (*see* Fig. 584). This is best done with a thin spatula after obliterating the vessels, special care being taken to secure the veins on the superior surface. Muscle grafts may be needed to stop bleeding from veins in the tentorium. By very cautious dissection with wet cotton pledgets, combined with retraction of the cut cerebellar surface, the lateral margin and posterior surface of the neurinoma is defined, as far as is yet possible, and vessels on its surface coagulated. The veins give no trouble, but the thin-walled arteries may be recalcitrant and need patient handling.

An incision is then made into the tumour and its interior gutted with a pituitary spoon. Free bleeding follows and is arrested with cotton packs ; exenteration may take some time because it is unsafe to curette unless it can be done in a dry field. This, thoroughly done, would terminate the original intracapsular operation of Cushing. He preferred the subtotal method because the radical extirpation in vogue before his day carried a mortality of at least 70 per cent. The difficulty is that some of these tumours are so fibrous that they cannot be broken up and eviscerated, while the removal of the centre from the soft variety does not always completely relieve the patient, so stiff is the capsule that remains behind. Results are better if a more thorough extirpation is carried out.

The alternatives that remain are : (*a*) considerable removal of the capsule by punching it away with the pituitary rongeurs ; (*b*) the complete removal of what remains of the tumour, after cutting its attachment to the internal auditory meatus. If complete extirpation is projected, the tumour must be detached from the petrous bone at an early stage. Although (*b*) is the ideal operation, the complete primary severance of the neurinoma from the porus internus requires the division, except by the very skilled, of the facial nerve as well as the auditory. This is a serious disadvantage, which a later spino-facial anastomosis does not completely remedy. The gratitude of the patient for his cure is too often tempered by annoyance at his disfigurement. It follows that as complete a removal as possible, leaving a little of the tumour capsule along the course of the facial

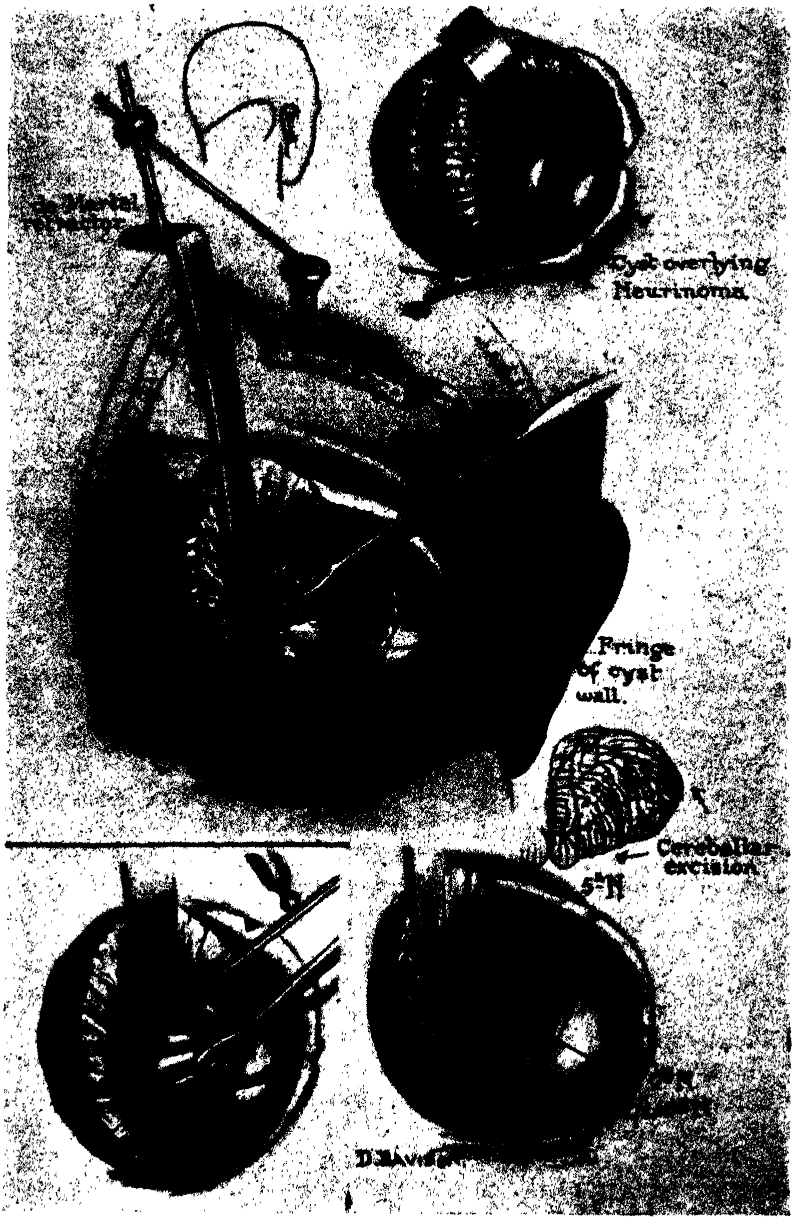

Fig. 584.—Stages in operation for acoustic neuroma. Average incision above ; in centre de Martel flap has been cut.

nerve (which always lies deep to the neuroma) is the better routine treatment. There is a reasonable prospect of being able to dissect the nerve off the deep surface after the neurinoma has been reduced in size and has become more mobile. The correct procedure is to dissect the tumour away from its attachments from below, not from its lateral margin.

The vascularity of the neurinomas makes even the subtotal extirpation of the tumour a time-consuming affair. The chief vessels come (1) caudally, from the vertebral or posterior inferior cerebellar arteries ; (2) medially by short branches from the basilar, and (3) rostrally, from the superior cerebellar artery. Bleeding is controlled chiefly by endotherm coagulation, by covering bleeding points with cotton pledgets and working elsewhere until the hæmorrhage has stopped, or by silver clips. At an early stage of the operation care must be taken to identify and to protect the vagal group of nerves which are closely applied to the caudal pole. The essentials of the operation are good access, as free an exposure of the dorsal surface of the neurinoma as possible, obtained by the repeated pulling of the capsule with the punch forceps laterally, coagulation of its vessels after brushing the cerebellum away, and the punching away of tumour tissue under vision as completely as is consistent with the preservation of the facial nerve.

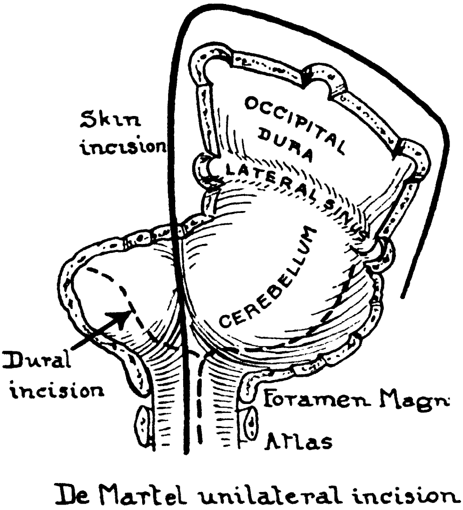

Fig. 585.—De Martel's unilateral osteoplastic flap for cerebellar approach.

Difficulties.—The surgeon cannot know how complete a removal will be possible until the operation is actively in progress. The rare cystic variety is the easiest of all. In some neglected cases (the acoustic neurinomas are frequently not diagnosed as early as they should be) the tumour may be very large and intracranial pressure very high. A wide decompression must then be made and the arch of the atlas removed. The de Martel incision (Fig. 585) gives beautiful exposure, and allows easy access both to the cerebello-pontine angle and to the tonsils. The only thing against it is that the cutting of the flap takes so much time that it is a formidable operation in itself. Technical difficulties arise from (1) extreme toughness ; (2) extreme softness ; (3) hæmorrhage ; (4) the protrusion, in late cases, of the superior pole of the tumour through the hiatus tentorii above and the pressure of its inferior pole into the foramen magnum below. Toughness is a better " fault " than softness ; whatever the consistence, hæmorrhage is always free. What is more, the substance of the soft neurinoma closely resembles brain tissue and the surgeon is faced with a dilemma :—has sufficient tissue been removed and what risk is there, in further deep curettage, of perforating the capsule or of contusing the closely applied brain stem ? The only safe procedure is to do nothing except under such direct vision as can only be secured by the very free exposure of the tumour. During radical extirpation the most dangerous steps are those necessary for the dissection of the neurinoma from the brain-stem, but if the semi-blunt pituitary punch is used, the tumour finally tends to pull laterally, so that access is at last obtained to the medial border ; there is then an opportunity for brushing the facial nerve off the deep surface and preserving it. In that way practically the whole tumour can be removed save for some tissue in the porus itself.

AFTER-CARE

The post-operative treatment of these cases is as for cerebellar tumours with two additions : (1) There may be difficulty in swallowing from mild trauma to the vagus. The patient should be fed with a spoon, but not before he has spoken ; the quality of the " vagal " voice can at once be detected. If there is dysphagia, a Ryle's tube should be introduced and all feeding done through it. Aspiration pneumonia (and cerebellar œdema) are the main causes of fatality. (2) The other morbid condition to be guarded against is neuroparalytic keratitis, which is a certainty if both the trigeminal root and the facial nerve have been damaged. Often there is some weakness of the facial musculature before operation, a weakness that the manipulations may temporarily enhance, with complete recovery later. The eye should be protected with a Buller's shield or, if the keratitis advances, the lids must be sutured.

RESULTS

Cushing's mortality for intracapsular enucleation was 13 per cent., but in his last series of 50 cases there were only 2 deaths. Olivecrona (1939) reported an 18·7 per cent. mortality for his series of 75 total extirpations ; the facial nerve had been preserved in 65 per cent. Olivecrona points out that the late results of the complete removals are greatly superior to those of intracapsular enucleation. Of Cushing's cases about one-third remained complete invalids and at least a quarter died from recurrence within five years.

PINEAL TUMOURS

The main approaches are the transcallosal of Dandy and the transventricular of Van Wagenen. It seems likely that a posterior approach after occipital lobectomy (Horrax) will prove itself to be superior to either, for it combines the advantages of both.

The transcallosal approach requires a right-sided occipital bone-flap ; the separation of the upper edge of the hemisphere from the sagittal sinus, after coagulating and dividing the entering veins ; gentle retraction of the mesial surface of the hemisphere from the falx ; and longitudinal section of the corpus callosum through to the velum interpositum (tela choroidea), which is incised parallel with and between the lesser veins of Galen. The tumour is now visible and is dissected out or removed piecemeal with punch forceps. Although most interesting cases clinically and pathologically, the results of operative attempts on pineal tumours are bad. It will often be wiser to make a decompression and employ deep X-radiation.

INTRAVENTRICULAR TUMOURS

It is not proposed to give any detailed account of intraventricular tumours, which are not common. Diagnosis can only be made by pneumography. For those in the third ventricle, which are chiefly paraphysial, " colloid " cysts or cystic upward extensions of Rathke pouch tumours, the approach is through the lateral ventricle opposite the foramen of Monro. A small bone flap only is needed, 4·0 cm. front and back of the coronal suture, and a cone of cortex removed through the whole thickness of the brain until the ventricle is opened. A hole 4·0 cm. in diameter allows full inspection and most tumours can easily be taken out through it. (Fig. 586.) The foramen of

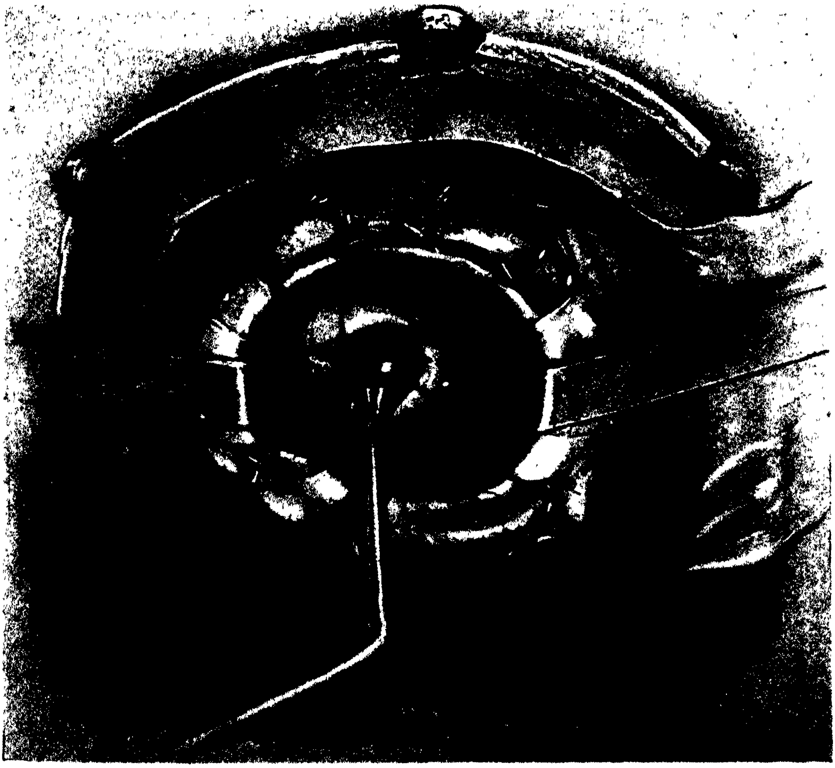

Fig. 586.—Transventricular exposure of colloid cyst of third ventricle.

Monro is generally seen at once, but if not it can be identified by tracing the veins on the septum pellucidum down till they arrive at it. Again, the choroid plexus will be seen running backwards from it. The cyst can be dissected out of the third ventricle more readily if the anterior pillar of the fornix is cut through to enlarge the opening. The cyst is seized, pulled through into the lateral ventricle and removed after its vascular connections have been secured. Tumours of the lateral ventricles are rare; they are usually meningiomas or circumscribed gliomas. Removal of the former gives excellent results; the prognosis of the gliomas depends on the extent to which the tumour is a local, almost pedunculated, product of the subependymal glia or is the sessile extension of a tumour in the basal ganglia or hemisphere.

Intraventricular operations are interesting interventions and not particularly difficult. Rigid asepsis is necessary, for infection of the ventricles may be only too easily induced by droplet infection from inquisitive and incautious onlookers.

OPERATIONS ON THE PITUITARY GLAND

Four types of pituitary tumour may demand operation: (1) the chromophobe adenoma (which is the most common); (2) the eosinophil adenoma of acromegaly; (3) the rare basophilic adenoma; (4) the congenital, and usually suprasellar, Rathke pouch tumour. The last will be dealt with separately, for its problem is a special one. The indications for operation are two: (1) failing vision due to chiasmal compression, and, more rarely, (2) signs of endocrine dysfunction; these disabilities may be present together. As a generalisation, it can be said that operations on the pituitary gland are much more commonly undertaken because of visual failure than because of endocrine defects. This is particularly the case with the chromophobe tumours, where the body changes are often unobtrusive; indeed, visual defects are almost the only means by which they make their presence known. This is absolutely true of females past the menopause. In younger ones amenorrhœa is the rule; obesity may or may not be a feature. Headache is often slight with this kind of adenoma; it is commoner in acromegaly, for it seems to be more often due to progressive bone alterations than to distension of the pituitary capsule.

Dyspituitarism may so adversely affect the patient's general health that the risk of operative intervention is increased. For example, in acromegaly there may be glycosuria, hyperthyroidism, and hyperpiesis; with chromophobe adenomas there is sometimes asthenia, a lowered metabolic rate, and hypopiesis. The great and general changes induced by basophilism are well-known. In acromegaly the subject may go through a long life without his vision becoming affected; only when the syndrome is clearly progressive is operation indicated, The rare basophilic adenoma (whose linkage with the clinical state of "basophilism" is admitted without complete certainty that it is the sole causal factor) calls for surgery on purely endocrine grounds. In such a case operation would be limited to removal by suction of the adenoma, thought to be accessible just beneath the diaphragma sellæ, or to the implantation of radon seeds (A. R. D. Pattison), a method which I know from experience to be quite useless for other types of pituitary adenomas. Chiasmal compression has not been observed in any case of basophilism so far reported.

With these indications clearly in mind, the next point is to define exactly what the surgeon expects to do at operation. No pituitary adenoma can be totally removed with a clearly defined capsule around it. The object of the operation is to free the chiasma from pressure by extirpating the contents of the tumour. A remarkably clean removal can be achieved by the curette and suction if the tumour is attacked in the proper way. First of all the approach must be decided upon. A much more complete removal can be made by the transfrontal operation than by the endonasal route. Indeed the latter is little more than a local decompression with incision of the capsule, though the surgeon may be tempted to do a lot more than this.

CHOICE OF OPERATION

The choice of operation lies between two classical operations, the trans-sphenoidal and the trans-frontal. Of the two, the former obtained the earliest popularity at the hands of Harvey Cushing, though in Europe the work of Hirsch of Vienna deserves mention. To-day the trans-frontal approach (which Sargent and Frazier always used and to which Cushing himself afterwards turned) is deservedly the more popular; the trans-sphenoidal is reserved for special circumstances.* The status of the two operations can best be gauged by stating their points, for and against.

Trans-sphenoidal approach.—(*a*) **Advantages.**—(1) The operation upsets the patient very little—scarcely more than an ordinary removal of the nasal septum. For that reason it is suitable for aged patients or those whose general condition does not recommend them for a severe operation. This is especially true of those with a high blood-pressure or cardio-renal damage, those who might more readily develop post-operative clots or become mentally upset after the frontal operation. (2) It is useful also in those neglected cases where very large tumours have been allowed to develop. These are always very formidable problems and probably are better left alone, especially if the patient is nearly blind. Some are worth a trans-sphenoidal decompression, as they may, if they are lucky, preserve their sight or even find it improved after what must always be a relatively inadequate operation. Some of the factors mentioned above enter into the question of the acromegalic cases with, now, an addition; (3) these patients are well known to possess very large frontal sinuses which may require the surgeon to cut the flap very high anteriorly, and this makes a transfrontal approach much more difficult. (4) Bilateral central scotomas suggest prefixation of the chiasma with the tumour largely hidden behind it. In such case the tumour can be more adequately dealt with by the trans-sphenoidal than by the transfrontal route.

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* Nager (Zurich) prefers the transethmoidal approach to the sphenoidal sinus and pituitary along the inner wall of the orbit (Chiari's method). The distance is shorter and the exposure is said to be better.

(*b*) **Disadvantages.**—The two chief disadvantages must be mentioned first: (1) a cramped and inadequate exposure; (2) the risk of sepsis and meningitis. In actual practice, if the right case is chosen, the view obtained of the adenoma by the inferior approach is better than would be imagined. But it needs a case in which the floor of the sella has been greatly depressed, until the sphenoidal air sinus is obliterated. In such circumstances the tumour seems to rest on the vomer and, when the wide flange of its base is removed, the tumour is at once seen and can be exposed for at least 2 by 1·5 cm. The capsule was, originally, only incised and nothing more done than this pure decompression. Of more recent years, removal of tumour contents has become more radical, but one cannot say exactly how much can be taken out with impunity from any given case. The best cases are those with cystic or very diffluent contents. A very hard tumour which does not sprout downwards at all when the capsule is incised will probably not derive any benefit. Unfortunately, this cannot be determined beforehand. When the sphenoidal air sinus, as demonstrated in the lateral X-ray, is very large, the operation is more difficult.

The incidence of sepsis in Cushing's series of 167 cases was 2 per cent. The risk is both immediate and late, for a patient may develop a pituitaritis and succumb to basal meningitis some weeks or months after what has had all the appearances of a very successful intervention. There may be other difficulties as well; the thick, heavy and vascular bones of the acromegalic make the operation difficult. And this intervention is absolutely contra-indicated if there is the slightest doubt of the nature of the lesion causing the visual upset, for no other than a pituitary adenoma can be attacked by this route. Because nasal infection vetoes this approach, a post-nasal swab should always be taken. On the whole, the disadvantages seem so overwhelming that it might be set aside as an operation which has played an important part in the evolution of the surgery of the pituitary but is now obsolete. But there is no doubt that it can occasionally be usefully applied to the carefully selected case.

Transfrontal operation.—(*a*) **Advantages.**—The lesion is much more easily seen and its nature identifiable. This route must be used if there is any doubt concerning the pathological nature of the agent causing the chiasmal compression, e.g. a meningioma, an aneurysm, or even the dilated third ventricle (though there is little risk of this last mistake in competent hands, for ventriculography excludes that possibility should clinical diagnostic means fail). Protrusions of tumour through the diaphragma can be fully dealt with and the commonly present subchiasmal nubbin pulled forwards from its hiding-place (*see* Fig. 588, p. 1232).

(*b*) **Disadvantages.**—There is no important disadvantage unless the chiasma is prefixed (as it is but rarely). Cushing suggested that bilateral central scotomata were indicative of pre-fixation, and Henderson's and my own views confirm this. In such cases the tumour compresses the macular fibres which decussate in the posterior edge of the chiasma. Given such fields, the transfrontal operation is likely to fail.

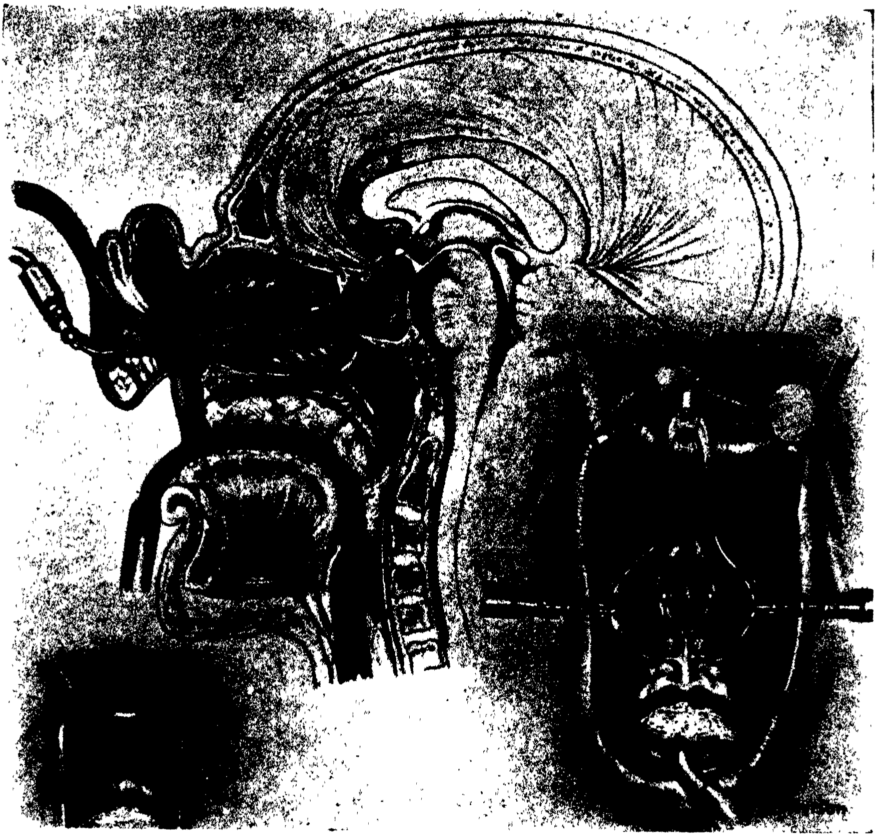

Fig. 587.—Trans-sphenoidal approach to a pituitary adenoma.

Technique of the trans-sphenoidal operation.—The steps in this operation can be seen in Fig. 587. The operation is best done in a darkened theatre. The nose is packed an hour beforehand with a 10 per cent. solution of cocaine and adrenalin. When endotracheal anæsthesia is going smoothly, the pharynx is packed with sterile gauze to prevent blood trickling down. The technical steps are those of the sub-mucous resection of the nasal septum, with some important differences. First, the septal separation is carried out after an incision has been made in the superior gingivolabial groove. This is carried to the bone and, by dissection from the base of the alveolar process upwards, the floor of the nose is reached on both sides. The maxillary spine is chiselled off, and the mucosa lifted from the floor of the nose and off the sides of the nasal septum in the usual way, care being taken not to " button-hole " the muco-perichondrial flaps. The septal separation and removal is carried out far back, indeed to the posterior end of the vomer, a nasal speculum with long narrow blades being a necessity. The second variant from the more usual septal operation is that the sub-mucous dissection is carried up along the vomer to the roof of the naso-pharnyx and on to the rostrum of the sphenoid. At this point, or before it, Cushing's special strong speculum, which is better if it carries its own illumination, is inserted and the blades separated as far as possible. If the nose is exceptionally narrow, more room can be obtained by the use of dilators, the larger sizes of Hegar's being useful, though Cushing had some short straight ones made. It is bad practice to remove the middle or inferior turbinates, as this must lead to nasal sepsis afterwards, and that at a time when it is important that nothing of the kind should occur. The shrinkage brought about by the pre-operative use of the cocaine-adrenalin pack is sufficient.

Sometimes the capsule of the tumour comes into view as soon as the alæ of the vomer are taken out ; at other times the anterior wall of the sphenoidal air sinus must be punched away with suitable long-handled forceps. The capsule ought to be visible for a good 1·5 cm. before it is incised. When this is done, the tumour tissue extrudes itself and at this point the original Cushing operation stopped. There is no doubt that the removal of the vomer allows the tumour to descend and to decompress the optic nerves by sinking lower into the roof of the naso-pharynx. The vomer is a strong bone and acts as a prop between the sphenoid and the hard palate. In my view it is the removal of the vomer rather than the opening into the sphenoid which is the most important step when the tumour is large.

The more adventurous may not be content with decompression alone but may insert a curette or the suction nozzle and remove a considerable quantity of tumour. In its ideal state—when no holes have been made in the mucosa of the nasal septum or in its reflected part where it becomes continuous with the roof of the naso-pharynx—there should be very little risk of infection. It should therefore be safe to do something more than merely incise the capsule of the tumour, but not if the septal dissection has gone badly. Philips has recommended that the capsule of the tumour should be grasped in punch forceps and pulled down until cerebro-spinal fluid escapes. The sphenoidal air sinus should have been practically obliterated by the descent of the tumour ; otherwise the case has been badly chosen. The operation is completed by the withdrawal of the speculum and the insertion in each nostril of sterile vaselined finger-stalls, packed with gauze.

In the post-operative stages the patient must not be allowed to blow his nose until the packs have been removed at the end of 24 hours. Phenate mouth washes are freely used and a nasal spray of Chloramine-T. in oil is given thrice daily. There is very little risk of a tuberal upset after this operation ; the one risk is sepsis. For that reason no patient with a septic mouth can be accepted for operation until the necessary extractions have been made and the tooth-sockets healed.

Technique of the transfrontal operation.—A general anæsthetic is usually employed. The patient lies supine with the base-line perpendicular to the floor. After the usual preliminaries, either a Trotter or a Souttar incision is made ; I prefer the former. There has been some difference in practice between different surgeons as to which side should be opened. It has been held that it is better to expose the side of better vision so that the better optic nerve can be seen and protected. Equally it has been held that the side of worse vision should be entered in case the patient has a pre-fixed chiasma (5 per cent. of normal individuals). In this state the optic chiasma may cover the front of the tumour so completely that it leaves the surgeon no room to reach the adenoma except by cutting an optic nerve, or by splitting the chiasma vertically. Such a step is very rarely necessary, and although I have done it I think I could have avoided it. It is very difficult to say when an optic nerve is irretrievably atrophied. Henderson has referred to one case of Cushing's in which the pre-operatively blind eye was eventually the only seeing eye. An experience such as that makes one very chary of sacrificing an optic nerve, since one cannot be sure that it might not finally be the better one. On the whole the surgeon who goes always from the right side, irrespective of vision, will find that he does very well.

A large bone flap is unnecessary. The skin flap is dissected down to a point a centimetre above the supraorbital ridges. The bone flap is cut and turned down in the usual manner. There is no need to transgress the mid-line, but in this anterior third of its course the sagittal sinus could be uncovered without much bleeding. The chief anxiety lies in the point of section anteriorly, *i.e.*, above the orbit. The antero-posterior radiographs must be carefully studied to determine the size of the frontal air sinus. An idea of its extent can be formed, and will be confirmed by careful inspection of the skull. The sinuses nearly always make a faint bulge, and the lowest drill hole must be sunk a few millimetres above this point. If they do not show any surface evidence great caution must be used in placing the burr-hole. Even if the sinus is avoided with the drill there is still a risk of opening it with the Gigli saw if the sinus has much of an extension laterally. None the less, the operator requires this supraorbital incision to be as low as possible, because he wishes to approach along the floor of the anterior fossa without a high ridge of bone to impede his view. The bone flap having been reflected, hinged on the temporal muscle, wet cotton or lintine must be placed over the lacunæ along the sagittal sinus to check bleeding. This having been stilled, and perhaps a "hitch-stitch" or two placed in position, the operation is proceeded with. (The gloves may be changed with advantage at this point.) The best exposure is obtained by the intradural route, but there is then more risk of damage to the brain by retractors, of snapping of veins entering the venous sinuses, and of post-operative œdema.

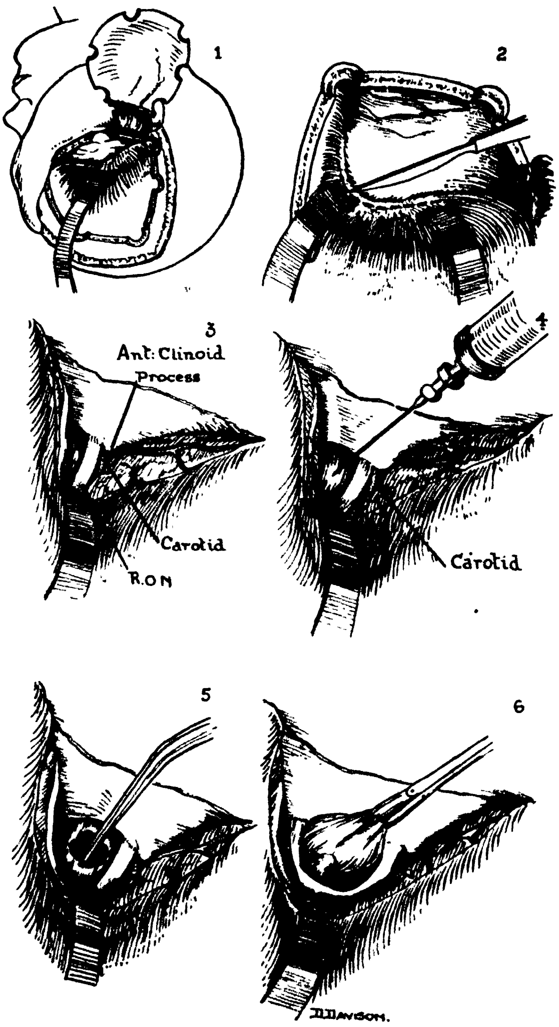

Fig. 588.—Trans-frontal approach to pituitary adenoma. Exposure, aspiration, suction of contents. Finally capsule pulled forward from beneath chiasma.

The better, if a slightly more difficult, route is the extradural. The frontal lobe is elevated from the roof of the orbit by dissection with wet cotton pledgets or dental swabs, the dural-covered brain being gently held up with a brain retractor. The dura peels off the roof of the orbit very easily once a start is made. It is best to begin on the outer side. A good headlight and illuminated retractors are needed as the lesser sphenoidal wing is approached and the dura can no longer be separated. The elevation must be carried medially to the base of the anterior clinoid process. The whole of the orbital plate of the frontal bone is now clearly visible; one or two small issuing vessels may have to be plugged with Horsley's wax. The dura is then put on the stretch and divided horizontally 3 mm. above its attachment to the sphenoidal wing (*see* Fig. 588). This must be very cautiously done; the incision is not carried to the extreme lateral limit for fear of injuring the middle cerebral vein where it joins the spheno-parietal sinus. As soon as the dura is opened there will be a free escape of cerebro-spinal fluid which makes the rest of the exposure much easier. Very narrow wet strips of lintine are inserted under the dura still to be cut and pushed along a little in advance of the scissors. The cut in the dura is thus carried towards the mid-line till it can get no further and then comes forward to the crista galli. The illuminated retractor is insinuated under the brain through the dural opening, after protection with lintine strips.

In the rarer cases where the tumour is very massive the brain cannot be sufficiently retracted to allow of good enough exposure. A ventricular trap helps a little and in extreme instances part of the right frontal lobe can be resected, but I have only once had to do that and then with complete success. I should prefer to break off the operation and proceed under local anæsthesia another day, but in the case referred to this had already been done. Ordinarily the right optic nerve comes easily into view just to the left of the anterior clinoid process, and to its inside the pituitary adenoma will be glimpsed. The exposure is improved gradually by shifting the retractor deeper towards the mid-line. The olfactory tract is seen and elevated with the brain. Often it pulls off, and an unavoidable unilateral anosmia follows, but it is of no great moment. The tumour and optic nerve are covered with a veil of arachnoid which must be torn through most carefully with a small rectangular hook. All these steps of the operation demand the utmost gentleness and sureness of hand. The ease of approach to the adenoma itself depends on the fixation of the chiasma. If it is prefixed (5 per cent. of individuals), the adenoma lies behind it and there may be the merest slit below it, insufficient to allow surgical manœuvres. The alternatives then are (*a*) to make a small vertical incision in the chiasma at its thinnest point through which to suck the adenoma away ; (*b*) to divide the optic nerve ; (*c*) to close the wound and re-operate by the trans-sphenoidal route. The choice will depend on the visual fields, the visual acuity in the nearest optic nerve, usually the right, and on the local condition under inspection. With normal and with post fixation all that is necessary to expose the tumour is to dissect the arachnoid off the right optic nerve and the tumour until a length rather more than 2 cm. is in view. It is wrong to insist on the display of the chiasma in every case, regardless of the size of the tumour and the accessibility of the chiasma. If the retraction is carried too far, post-operative hypothalamic disturbances are much more likely, and may cause a fatality in an operation that has gone very well and does not merit such a result. Sometimes adenomatous tissue tracks under the nerve, elevating it, to appear on its outer side bulging against the artery. Vision will not be restored unless such a protrusion is dealt with, but first the main adenoma must be exenterated. The surgeon, unless very expert, deals very circumspectly with tumour nubbins on the outer side of the optic nerve for fear of injury to the carotid artery. When the tumour has been exposed to the inner side of the optic nerve, a vessel or so, usually of small size, will be seen coursing over its capsule. These may be coagulated with the diathermy but great care must be taken not to transmit the heat to the optic nerve.

The capsule of the adenoma (the stretched diaphragma sellæ) is incised with a narrow-bladed knife after aspiration has ensured that the tumour is not an aneurysm. Soft tumour tissue usually escapes at once. With a blunt Cushing pituitary spoon some of the contents are carefully removed for microscopy and the sucker nozzle inserted. It is possible thus to remove the whole contents of the fossa very easily and expeditiously. The only difficult place is under the right optic nerve, but a special nozzle with a lateral bend at its tip (Olivecrona) makes the removal of tumour tissue from that situation more easy. Often the interior of the sella is now felt, and even seen, to be quite smooth, all tumour tissue having gone. The capsule usually collapses and can be coaxed into the bottom of the sella. It should be seized with fine angled forceps and drawn forwards from beneath the chiasma ; by so doing an appreciable nubbin of tumour can often be pulled out from there, or from beneath the optic nerves, and removed. Some of the capsule may be cut away as a last step, but this depends on the size of the tumour and on the ease of doing it. If it looks very difficult it will not be safe.

The harder tumours are much more difficult, and for some a sharp spoon or punch-forceps will have to be employed. Unless these are used with great caution the optic apparatus may be damaged. The pituitary is a vascular gland and usually considerable bleeding attends the removal even of the softest tumours. The vessels are the short, fine tributaries to the anterior lobe (pars buccalis) from the internal carotid artery in its intracavernous course. A piece of muscle can be cut from the temporalis, placed in the shell of the tumour and covered with lintine whilst the sucker keeps the field dry. It is understood that all this time the optic nerves are most carefully avoided. It may be necessary to wait some time before all bleeding is arrested—from 10 even to 30 minutes. The wound must not be closed until the bleeding has definitely stopped and washings come back clear after removal of the muscle fragment. The bone flap is replaced with a rubber drain beneath the bone. It is a good plan to save the bone dust from the burr holes during entry and replace it in those of the mid-line, where lie the two holes which are most likely to leave unsightly depressions.

Difficulties.—1. **Opening the frontal sinus.**—Unless the mucosa is actually torn there is little risk of infection. I have exposed the mucosa a few times and once or twice inadvertently opened it, but without mishap. My practice is to place a small piece of beaten muscle over the mucosa and then wax it over. It is not good to plug wax freely into the sinus, as it seems to me that wax may cause trouble rather than prevent it. At the close a piece of pericranium is cut and laid over the site of the injury to the sinus. The bone flap fits back so, accurately that this little graft is jammed and cannot slip away. Such manœuvres have so far invariably proved successful. If the sinus were infected at the time of operation it would of course be impossible to proceed further. Study of the X-rays beforehand gives information on that point.

2. **A greatly adherent dura.**—This can be a difficulty with all bone flaps, but especially in old people. When the bone is being broken back the surgeon can at once feel whether the dura is adherent and can separate it by blunt dissection. Tears in the dura do not matter much ; the danger is that the cortex may be injured and hæmorrhage occur. The only dangerous place is along the sagittal sinus and just beside it, where the parasagittal veins could be pulled off. If that happens, the lateral ends are coagulated and the points of entry into the sinus covered most carefully with adequate muscle grafts.

3. **Imperfect exposure of the tumour.**—Pituitary tumours develop from beneath the chiasma and present anteriorly to it, but the rare pre-fixed chiasma makes difficulties whatever the skill of the operator. Some pituitary tumours are very florid, forming large extensions which add greatly to the difficulties and dangers of the operation.

Complications.—The commonest is post-operative clot (p. 1205). Apart from this, the only important ones are the tuberal (hypothalamic) crises or disturbances that only occasionally mar the smoothness of recovery. At their worst they will cause a fatality whatever is done. The patient then never fully regains consciousness, the temperature steadily rises to 107° or over ; there is no sweating, but the face is flushed and the pulse and respirations become very rapid. In the milder cases, cold sponging or wrapping in a wet sheet and, especially, rectal irrigation with ice-water, powdered aspirin by mouth, and pituitrin hypodermically, will combine to bring the temperature down and tide the patient over. Measures must be instituted if the temperature exceeds 102°, when all covering except a sheet is removed from the bed. They will be increasingly energetic if the pyrexia proves difficult to control. Polyuria and polydipsia may also cause discomfort, but can be effectively countered by the hypodermic administration of pituitrin.

If all has gone well, the tube is removed at the end of 48 hours, the sutures removed on the third day, and the patient allowed out of bed before the week is over. Even if an osteoplastic flap is cut, the scar is negligible if the skin is carefully sutured in layers and especially if the frontal limb of the incision is made dead in the centre of the forehead.

Results.—The results of the transfrontal operation are very good. The mortality is little if anything higher than the trans-sphenoidal at the present day, 4–5 per cent.[*] I had a run of 37 with no deaths and then lost an old man with a very advanced tumour which ought to have been left alone. Indeed, most fatalities occur in the neglected cases where the cause of the visual loss has not been appreciated until too late—an occurrence all too common. It is very difficult indeed to know with certainty when a pituitary tumour is definitely inoperable; pneumography is a great help for it demonstrates the size of the tumour. It is often in the worst cases that the greatest pressure is put on the surgeon, either by medical colleagues or by the sufferer himself. The causes of mortality are post-operative clots (early recognition will often avert disaster), an uncontrollable hypothalamic crisis, massive size, or extension. The immediate improvement of vision is much greater by the transfrontal than by the transnasal operation, unless the tumour is cystic, when the effects are equal. Little improvement will result when the tumour has compressed the optic nerves for so long that atrophy has occurred. Some very pale nerves are anæmic rather than degenerated, but the length of history will usually give a very good indication of what can be hoped for in the way of recovery. Even in these bad cases, tumour removal may help to delay complete blindness. Deep X-ray therapy is instituted post-operatively in all cases. It is not a good primary method of dealing with pituitary adenomas, except the acromegalic without visual loss, because it may cause an acute swelling of the tumour.

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[*] The mortality is highest (maybe 30 per cent.) in cases with extensions of adenomatous tissue into the hypothalamic, temporal, or frontal regions; it is lowest with the commoner small chromophobe adenomas with classical field defects and no headache (about 2 per cent.).

Hypophyseal Duct or Pituitary Anlage Tumours

These tumours exist in two forms, pre- and post-chiasmal. The former are largely intrasellar, producing symptoms and signs similar to those of a pituitary adenoma, the only difference being, as a rule, the youth of the patient or his infantile state and the presence of intra- or local supra-sellar calcification as proved by X-rays.

Pre-chiasmal.—This variety is dealt with by the transfrontal pituitary approach just described. The tumour can usually be completely removed, once it has been freed by careful dissection from the chiasma and carotid arteries. The capsule is tough enough to be dragged out completely, though sometimes an optic nerve must be cut. This is a more justifiable procedure in the dislodgement of one of these anlage tumours than with an adenoma.

Post-chiasmal.—In the second type the tumour rises above the sella largely behind the chiasma and produces homonymous rather than bitemporal field defects. It is usually capped by a cyst, which may extend high into the third ventricle and lead to obstructive hydrocephalus, with papillœdema instead of the optic atrophy which is the sign of pre-chiasmal lesions. It should be stated at once, however, that the surgeon cannot accept all these tumours for operation. If they are heavily calcified, they are usually solid, cement-like, brittle adamantinomas and should be left alone. The less calcification the better, for that indicates a cyst which may rise high into the third ventricle. The approach to these cysts is through the lateral ventricle, which is always dilated. A brief description of the approach is given under " Intraventricular Tumours " (p. 1225). The results of operation are good for the pre-chiasmal intrasellar kind, but variable to bad for the commoner second type, depending on the extent of the tumour conglomerate. Some of these tumours have all the histological appearances of basal-celled carcinomas.

SUPRASELLAR MENINGIOMAS

These tumours, whose recognition as a definite group we owe to Holmes and Sargent and to Harvey Cushing, produce the same visual changes as pituitary adenomas without the sellar changes. They spring from the tuberculum sellæ and compress the chiasma from before backwards. The approach to them is the same as to the adenoma, except that it is best done intradurally. The operation is undertaken on the side of better vision, as the opposite optic nerve is much more difficult to see than in pituitary adenomas and is, therefore, in danger. These tumours are always very difficult surgically and may appear impossible, but if they are dealt with carefully and methodically they are usually removable. The meningioma usually has to be reduced considerably in size before mobilization, because its attachment cannot at first be clearly seen. Vessels on the surface are coagulated, and portions of the tumour punched away with the pituitary punch-forceps, or looped with the cutting current, so as to reduce bulk. Next, the attachment to the tuberculum sellæ and pituitary diaphragm is sought, and little by little cut through with the hook and endotherm applied to its handle ; when freed in this way the tumour can be withdrawn. During the extraction of this residual portion it is important to free it from the optic nerves and chiasma by very gentle blunt dissection. The area of origin from the dura is heavily coagulated at the close, to kill remaining tumour cells and arrest oozing from perforating nutrient vessels.

DECOMPRESSION

We owe to Horsley the decompressive operations which were originally performed to reduce headache and relieve the optic nerve-heads of papillœdema. Nowadays they are more often the by-products of partial tumour removals or negative explorations, and what was once the commonest of all neuro-surgical operations is now rarely performed as an end in itself. This change is due to (*a*) more exact localization of tumours by ventriculography ; (*b*) a better understanding of their nature and life history. The result is that the surgeon feels much more confident of finding a suspected tumour and of doing something worth while with it. The cranial cavity is the only place where even a subtotal tumour removal is of considerable benefit to the patient.

It is a mistaken notion that a patient who is unconscious and has a tumour is in that state from high intracranial pressure alone. Confused thinking on this point led to the conclusion that miraculous cure would follow a decompression. These desperate states are usually due to destruction of neural tissues by malignant tumours, and pressure plays a relatively unimportant part. This is especially true in persons past middle life (when glioblastomas and secondary tumours are so common). It will be realized that merely to decompress a benign tumour would be a work only part done.

Decompression, then, should be reserved for the following :—(*a*) for serous meningitis, where there are pressure changes and danger to vision from choked discs, but no actual tumour ; (*b*) as a step to reduce pressure in a patient known to have a removable tumour (such as an olfactory groove meningioma), but where the pressure is so high that it will make removal impossible ; (*c*) as a safety measure at the close of most tumour removals in order to allow for traumatic œdema ; (*d*) as a stage in the treatment of the encapsulated cerebral abscess ; (*e*) very rarely, to relieve pain in malignant and otherwise inoperable gliomas ; morphia is a better therapeutic means.

A decompression may be supra or infra-tentorial but, because most cerebellar tumours are benign, operation by the suboccipital route will rarely be purely decompressive. If it is, it takes the form of the usual cerebellar bilateral approach. The supra-tentorial decompression differs from operations for tumour by being purely per-temporal.

In 1905 Cushing published an account of the right-sided sub-temporal decompression. It was right-sided to avoid the aphasia which is apt to follow prolapse of the left temporal lobe ; it was low to avoid herniation of the motor area ; it was beneath the temporal muscle to obtain as much covering as possible for the otherwise unsupported brain. The importance of these points can only be properly appreciated by the surgeon familiar with case after case of high pressure. Woe betide him who thinks that the steps of the modern surgical closure are over-elaborate and unnecessary.

Sub-temporal Decompression

Any decompression is most effective when it is placed over the actual tumour. Hence the sub-temporal operation is best, theoretically, for right temporal tumours, for a tumour always tends to drift towards the low pressure zone (Trotter) and may cause neurological signs to appear that reveal its hitherto unknown site (Cairns). It must never be done for a sub-tentorial tumour, for it then relieves pressure very little, the hydrocephalic ventricle blows out the temporal lobe without lowering the pressure very much and causes it to necrose. This happens, indeed, in all herniations under high pressure ; hence the need for careful selection of a silent area and the protection of those with important functions. The original horse-shoe or omega flap has been given up, because it entailed severance of the frontal branches of the facial nerve. A large " question-mark " incision is made, convex backwards, commencing 3 cm. above and behind the external angular process, following a course 1 cm. or so above the temporal crest. The scalp is cut with the routine technique for hæmostasis and dissected off the temporal fascia downwards and forwards as low as possible. In the classical sub-temporal decompression, the fascia and muscle were next split vertically and the bone removed from beneath. In practice this proves to be a very difficult procedure and usually ends either in an opening so small that it was hardly worth making, or in the muscles being pulled about so much that they are difficult to suture. It is better to make an incision 1 cm. above the temporal crest and most carefully rongeur the pericranium downwards as far as the muscle attachment and then scrape it from the bone, the whole in one large and undamaged musculo-aponeurotic sheet. Four artery forceps applied to the edges keep it under tension so that it does not shrink. A hole is now drilled in the bone, and the temporal squame is nibbled away downwards to the floor of the middle fossa. The most useful forceps are Horsley's, Wilm's, Trotter's, and the double-acting Stille type. The opening should be centred above the pinna. If it is carried too far forwards the decompression causes an unsightly bulge which no head-dress will hide. A bone opening some 5 cm. high by 6 cm. long is desired. After coagulating the meningeal vessels crossing the exposed dura, and waxing any bleeding from the bone, the wound edge is sealed off with fresh towels, the gloves changed (because tears or punctures are likely in all work on a substance as hard as bone) and the dura incised. It can be opened the whole length of the incision, according to the technique described on p. 1197, but it should not be opened higher than the Sylvian veins, which are very easily identified. If pressure is great, a ventricular tap should be made through the second temporal convolution in the posterior part of the decompressive opening or through a fresh burr-hole at Keen's point—3 cm. above and 3 cm. behind the external auditory meatus. Bleeding from the dura is now controlled and, after washing over with Ringer's solution, the temporal musculo-aponeurotic sheet is sutured back with multiple points of fine silk, 1 cm. apart. The skin is closed to two layers as usual. I have occasionally cut a small flap in the temporal region instead of performing the operation just described, but although it is an entirely satisfactory method, superior to the intermusculo-temporal, it is no better than that here described.

The results of pure decompression for tumour are worse than attempts on the lesion itself. When the tumour is temporal a lobectomy is better because of the increased space afforded to the brain—" internal decompression " (*see* Fig. 575, p. 1200).

THE SURGERY OF TRIGEMINAL NEURALGIA

The operation of choice for true paroxysmal neuralgia is division of the sensory root of the Gasserian ganglion. This, the Spiller-Frazier operation, has entirely superseded the excision of the ganglion of earlier days, though the modern operation has evolved from it. Operation and alcohol injection are not really rival methods, but rather alternative, and each has its place. Both demand a high degree of skill. The modern operation embodies two refinements that ganglionectomy did not have : sparing the motor root, and fractional section of the sensory fibres, *i.e.*, cutting only such rootlets as are concerned in the conduction of the painful impulses in each particular case. This depends on the fact that the fibres entering the ganglion from the periphery pass backwards from cell-stations through into the sensory root in much the same order, from above downwards, as they entered it. The ophthalmic fibres are uppermost, the mandibular fibres lowermost, in the root as well as in the periphery and in the ganglion. This anatomical plan is not absolutely rigid and, as the root passes backwards, a certain amount of interchange and rotation takes place. None the less, great use can be made of this arrangement, for it is possible to spare with considerable accuracy the fibres destined for the eye, thus reducing to a minimum the risks of neuro-paralytic keratitis. When alcohol is injected into the ganglion its diffusion cannot be controlled sufficiently to allow the " fractional " destruction of cells and fibres and, though patchy anæsthesia often follows the use of small quantities, its distribution cannot be well enough ordered to make it a method of precision. The advantage of operation becomes clear ; only thus can one make a selective and managed de-afferentation of the face.

The common practice amongst neuro-surgeons to-day is to perform fractional root sections for patients with tic limited to one or two divisions (usually the second or third) and to inject the ganglion in the rarer cases where all three are affected.

Section of the Sensory Root of Trigeminus

The operation is always carried out with the patient seated in a dental chair, which may be equipped with a special head-rest. The advantages of this position are many : for one thing, bleeding is minimized ; for another, anatomical relationships are invariably memorized as if the subject were in the erect posture, and it is most important that they should be very clearly in mind during the stages of exposure of the sensory root. The only possible disadvantage is that of anæsthesia. The operation can be done under any anæsthetic ; the best is intratracheal gas and oxygen, preceded by omnopon-scopolamine and avertin. The drop in blood pressure, which follows avertin and is accentuated by the erect posture, may cause anxiety, though I have never known any actual harm from it. Individuals vary a good deal in their susceptibility, so that it is well to be able to lower the head if there should be too alarming a fall in pressure. I have used local anæsthesia many times but have given it up. The patient's eyes are covered, as soon as he is anæsthetized, with sterilized rubber tissue, to prevent damage to the cornea. If one side only of the head is shaved, there are never last-moment doubts as to which is the affected side. As soon as he is anæsthetized the patient is seated in the chair. A long sheet is carried round the knees, making its chief pressure at the level of the tibial tuberosities and fastened to the chair behind to prevent slipping. The head-rest is adjusted to the neck so that the mastoids rest against the pads, and the head is fastened by a strip of elastoplast on the side away from the operation. It is important that the head should be fixed so that the face looks directly forwards and is not tilted up towards the ceiling. The incision is marked out with iodine before any drapes are applied (this is important) and then scratched in. A piece of cotton wetted with alcohol is placed in the external auditory meatus.

Technique.—The incision is shaped like a hockey-stick (*see* Fig. 589), curving backwards above ; the vertical limb is 2½ ins. and the turn backwards about an inch long. It should be placed immediately behind the half-way mark between the external auditory meatus and the external angular process. If it is further back than that the foramen spinosum seems always to be very far forward, and consequently the middle meningeal artery is more difficult to secure. The incision just reaches the upper edge of the zygoma, but no more, or seventh nerve fibres to the muscles of the forehead will be cut. Note must be taken of their probable course in marking out the skin incision, and it may be well to curve the lower centimetre of the incision obliquely backwards to avoid them (as in Fig. 589). Patients' heads vary, and incisions must be made to suit them. The incision is marked out with iodine, after which novocain-adrenalin is infiltrated. A 10-inch square of lint wrung out of perchloride solution (1–1,000) is next sutured to the skin to exclude the pinna. After placing the wet towels carefully and fixing them in position, the whole patient and chair are draped. A high instrument tray is placed alongside the patient's head on the opposite side, level with the vertex, and the drapes are thrown over that. In this way the patient's head is enclosed in a small tent, to which the anæsthetist has access to keep track of blood pressure, respirations and so forth. The tray is very useful as a resting place at a conveniently high level for instruments.

The lint is cut with scissors over the line of the skin incision, which is carried down to the temporal fascia in the usual way. Artery forceps on the edges of the incision are a nuisance, and are better replaced by Michel clips, compressing the cut edges 1 cm. apart. A large branch of the temporal artery is caught and tied at once with fine, black, iron-dyed silk. The scalp is next freed from the temporal fascia by sharp and blunt gauze dissection until a flap of temporal fascia can be cut and dissected off the muscle. This can be very neatly done with the diathermy needle. The temporal muscle is split with the same instrument from top to bottom of the wound and a self-retaining retractor inserted. The temporal muscle is separated from the bone and pushed forwards and backwards, care being taken not to pull it off its superior attachments. If it is so thick that it interferes with the proper exposure of the bone it may have to be divided below in a forward direction for a centimetre. The bone must be cleared downwards to the inferior temporal crest, that is, deep to the zygoma, especially anteriorly. An area of bone some 4 cm. in diameter having been bared, and the self-retaining retractor re-adjusted, the bone is drilled and removed after careful separation of the dura. This is often very easily done ; if it should be difficult, the separation must be made with the utmost care and patience ; no corner-cutting is permissible here. This is particularly true of the point where the dura lining the lateral wall of the skull changes over to that of the base. By keeping the tip of a curved dissector, such as Adson's, closely pressed against the bone, the dura can eventually be coaxed away. Any sign of shredding of the dura is a challenge to technique which patience will overcome. The bone removal must be carried very low down, because entrance is effected along the floor of the middle fossa. The dura is now stripped off the base ; this is much easier than the separation from the lateral wall and once it has started to come up it continues to do so readily under the pressure of a small moist dental swab. These swabs are great helps in the dissection of the sensory root and should have long coloured strings so that they do not get overlooked when left in place for the temporary arrest of hæmorrhage. An electrically-lit retractor is inserted now, or even earlier, to hold up the temporal lobe.

The next objective is the middle meningeal artery. It may have already caused some bleeding, especially if the bone removal has been carried far upwards and forwards. It is easily controlled by electro-coagulation, or by wax if its tunnel in the bone at the pterion is broken into. The groove in the floor of the middle fossa leads eventually to the foramen spinosum and thus forms a guide. Here the emergent artery is dissected free and the foramen plugged with a small piece of boiled tapered match-stick ; these sticks should be prepared beforehand. Alternatively, the small square-ended hook is pushed into the foramen and the handle touched with the diathermy. The direction in which the artery traverses the bone is not constant, but is always quite easy to discover. The artery is cut through in the foramen with a sharp-pointed tenotome, the tip of the knife within its rim. There is rarely any bleeding from the upper end ; if there is, it is at once stopped by the electric current. The middle meningeal vein does not accompany the artery through the foramen spinosum, it leaves through the foramen ovale. Unless it is coagulated as it lies in the dura deep in the middle fossa, it will bleed when the dura is disturbed in the next move.

Just in front of and deeper than the foramen spinosum is the foramen ovale. This foramen is filled by the third division, which cannot be seen until the dura is stripped from it. It is important that the third division should be approached slightly from the front. The worst thing that can be done is to come on it too far back, for blunt dissection then will almost certainly drag on the petrosal nerve, and facial paralysis will result. Moreover, the ganglion may be lifted up in its sheath, a thoroughly bad thing. By blunt dissection the dura covering the division is swept upwards and backwards from the anterior margin of the foramen ovale. (At this point venous bleeding may be encountered if the meningeal vein has not been dealt with.) Often the dura slides up at once but, if it adheres, light touches with the knife free it, and the fibres of the third division can then be identified. The dura is then pushed up again, but it will soon stick, and a new incision is made to start it off once more. A metal blunt dissector may be used cautiously to help the elevation of the dura from the mandibular division once the nerve fibres have been seen. Touches with the knife blade are very important, and the most difficult point in the craft of this operation is to know just when and where to make them. In general they are made over the front and along the outer side of the third division and the ganglion, but they must not be deep enough to cut the nerve. The dura also needs elevation from the petrous bone on the outer side of the third division. Hence the light cuts with the narrow-bladed knife must be prolonged externally along the petrous bone. If the dura at this point is separated by forceful pushes with a wet dental swab the great superficial petrosal nerve is almost certain to be badly pulled; facial paralysis results. By sharp dissection it is possible to leave the petrosal nerve undisturbed on the petrous bone with a thin layer of dura attached to it; there is a natural line of cleavage there between two layers of dura. The petrous bone is bared again above this point up to the superior petrosal sinus. Sharp dissection will be necessary in front over the whole width of the third division, medially as well as on the outer side, if a proper exposure of the ganglion and root is to be effected. The division in its intracranial course is flat, with its anterior surface facing outwards and forwards, so that its borders are antero-medial and postero-lateral. (Fig. 589.) Some bleeding from a vein leading into the cavernous sinus may be started, but is easily stopped by a muscle graft. The arachnoid-covered root is finally bared; the membrane is commonly so opaque that the actual fibres cannot be seen through it. As a general rule it can be said that, in order to expose it, at least 2·5 cm. of nerve must be laid bare above the foramen ovale.

It is recognized by two things: firstly, the cerebro-spinal fluid layer surrounding it makes it appear slightly darker than the compact third division itself; secondly, the pulsation of the fluid can be recognized. As soon as the root is uncovered, the arachnoid is incised; cerebro-spinal fluid escapes and is sucked away. The sucker and the illuminated retractor together make this operation a comfortable one. The higher the root has been dissected up towards the top of the petrous bone, the easier it is to pick up its individual fibres. The knife must not be used to cut through the root because the carotid artery in its canal in the petrous bone is not always fully roofed. Such fibres of the root as are to be divided are picked up with a fine hook and torn or cut through with Adson's guillotine. There is rarely any bleeding when this is done; if there is, the cut has probably been made into the ganglion or even into the third division, i.e., not far enough back. If the section is made, fibre by fibre, with the hook, the motor root will be seen behind the sensory fibres ; usually it is a double band of compact nerve, quite unlike the extremely fine strands of the sensory root, and running more vertically. The fibres to the eye must be left uncut (indeed they are often left inadvertently, being sometimes quite separate from the other fascicles). If it is especially desired to cut them (as in the rare neuralgias limited to the first division) they must be sought with a small blunt hook far up and medially. In cases of severe second division neuralgia the operator ensures that the correct

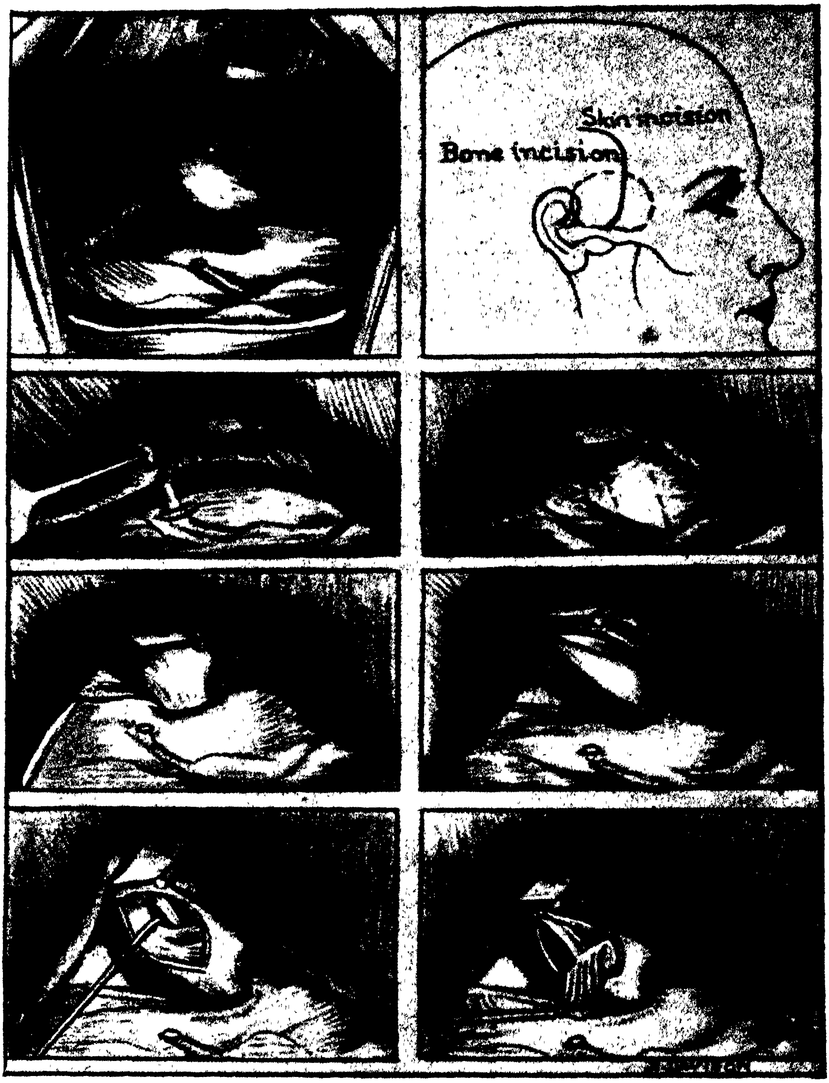


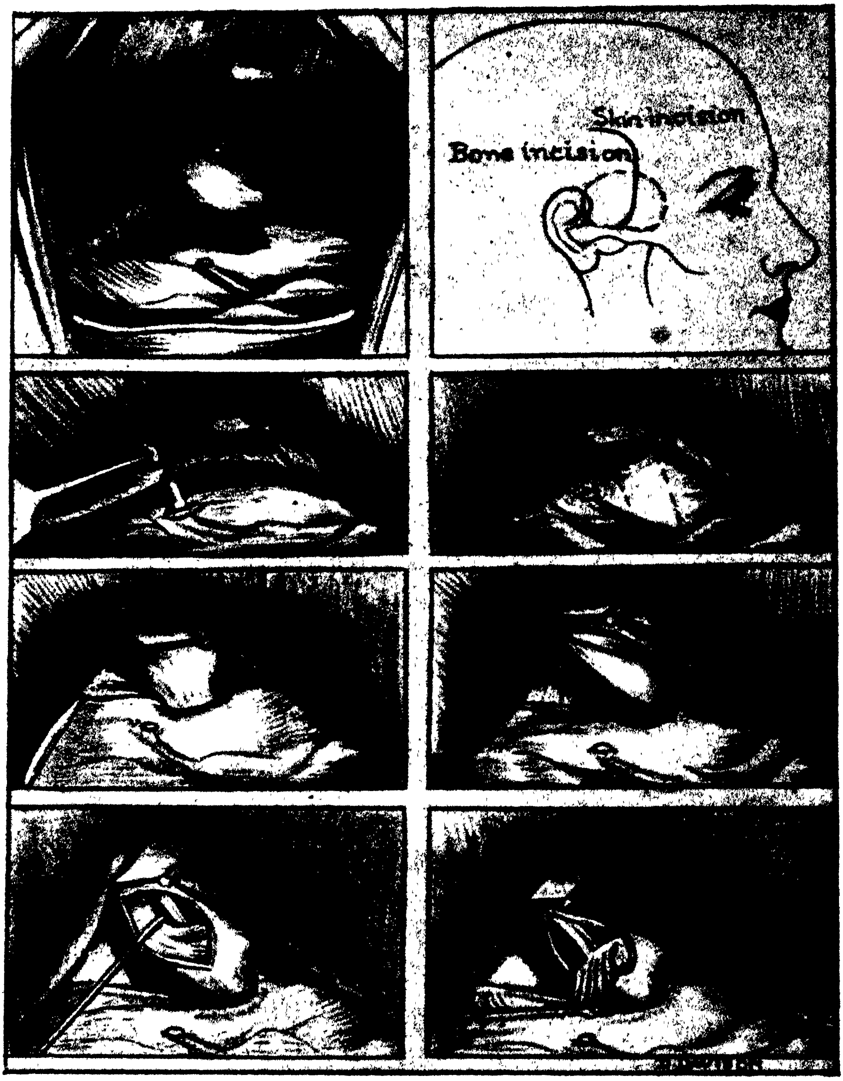
Fig. 589.—Fractional division of sensory trigeminal root, sparing motor root. Stages in the exposure.

fibres have been chosen by tracing them forward to the origin of this division, from the distal side of the ganglion. He can estimate whether the fibres which he intends to divide seem to be clearly destined for that division. The procedure is similar for neuralgias of the third division only.

Fractional divisions, that is section of the root fibres proper to the second or third division, are most accurately made very close to the point of insertion of the root fibres into the ganglion. In some cases, to make assurance doubly sure, the second division is cleared as it enters the foramen rotundum and coagulated electrically. Although a very pretty operation can be done by freeing the whole root very far centrally, the root being first pulled gently down by a hook above, and then freed and raised up from below, fractional divisions at this level sometimes lead to very curious and patchy anæsthesias of the face.

The operation is now over except for the insertion of muscle grafts. One is placed in the open sheath of Meckel's cave, thus insulating the middle from the posterior fossa, preventing cerebro-spinal fluid from leaking from the latter or blood entering from the former. Any other doubtful bleeding point is also treated with a muscle graft, a 24-hour small drain is inserted, and the wound is closed in four layers (muscle, fascia, aponeurosis, and skin). In an easy case the operation can be carried through in about 40 minutes, and can indeed be done, by those who make a point of it, in a much shorter time. It is the most admirable of all operations for training the surgeon in the special technique of neuro-surgery.

Difficulties.—(*a*) The chief difficulty in the early stages of the operation is adhesion of the dura to the lateral wall of the skull. Unless great pains are taken, the dura may be torn through and the temporal lobe lacerated. It is difficult to recover from such a mishap, but it can be done and no harm ensue. (*b*) The next difficulty is to secure the middle meningeal artery, and indeed most of the remaining difficulties are concerned with bleeding. The entrance of the artery into the skull may be obscured by one of the little hillocks of bone which abound in the middle fossa. If one is in the way, it can be very easily chiselled off. It is immaterial whether the artery is coagulated electrically or occluded with a peg. When the arterial groove is deep its margins are often sharp, and when the artery is lifted out it may start to bleed from small punctures in its wall. This bleeding can be controlled by pressure with the end of the lighted retractor until the vessel is coagulated deeper in. Some surgeons confess that, having had so much trouble with the middle meningeal artery, they have made a routine practice of tying the external carotid artery in the neck. This is not necessary if the niceties are observed. (*c*) The next point at which there may be difficulties is the clearance of the dura from the third division. It is important to remember that the middle meningeal vein runs out through the foramen ovale, where it may be joined by a vein from the superior petrosal sinus will be seen behind the sensory fibres ; usually it is a double band of compact nerve, quite unlike the extremely fine strands of the sensory root, and running more vertically. The fibres to the eye must be left uncut (indeed they are often left inadvertently, being sometimes quite separate from the other fascicles). If it is especially desired to cut them (as in the rare neuralgias limited to the first division) they must be sought with a small blunt hook far up and medially. In cases of severe second division neuralgia the operator ensures that the correct



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Complications.—There are only two complications worth mentioning: facial paralysis and keratitis neuro-paralytica. The former is uncommon. It is due to traction on the petrosal nerve, and transmission of the drag to the seventh nerve at its geniculate ganglion. This injury can always be avoided if the approach is made from the front of the third division and if sharp dissection is carried from that point outwards and backwards, rather than from without inwards. The petrosal nerve can be cut in order to avoid any pull on it, but it is better not to do so, for its section leads to a dry nose and diminished tear secretion. Neuro-paralytic keratitis does not occur with fractional sections of the sensory root; it is most likely to appear in the earliest days after complete denervation, but it may not make its appearance until weeks or months later. (*See* p. 1249.)

It must be admitted that, after partial sections, an occasional recurrence takes place in the still sensitive area. Fortunately, re-operations are extremely easy save for the difficulty of dissecting the temporal muscle off the dura, and of freeing the edge of the opening in the bone the whole way round. The deeper stages of the operation have a habit of being simple in the extreme.

In an average case the patient is allowed up on the second or third day, and can be sent home at the end of the week. The mortality of the operation is less than 1 per cent.

ALCOHOL INJECTIONS INTO THE GASSERIAN GANGLION

The method of choice is the anterior of Härtel, when the needle is introduced through the cheek into the foramen ovale and passes backwards obliquely into the ganglion. The lateral approach is not so uniformly satisfactory. All alcohol injections should be done under omnopon-scopolamine medication. In old subjects gr. $\frac{1}{3}$–1/300 respectively is quite sufficient; indeed, with larger doses they become so sleepy that they can no longer co-operate helpfully. The skin of the cheek is washed over with alcohol. I have found it imperative to use certain surface markings. The zygoma is carefully palpated and its mid-point marked by a vertical line of iodine. By checking the inclination of the needle with which the ganglion is being sought in relation to this skin-mark the worst errors will be avoided; the needle should be directed at it or even slightly in front of it. (Fig. 590.) It should never be directed further back than this mid-point. The usual fault is to direct the needle so far backwards that the carotid or even the jugular foramen may be reached instead of the foramen ovale. I have seen vagal and hypoglossal paralyses inflicted—a distressing mistake that could have been avoided had the slope of the needle been corrected in reference to a surface marking.

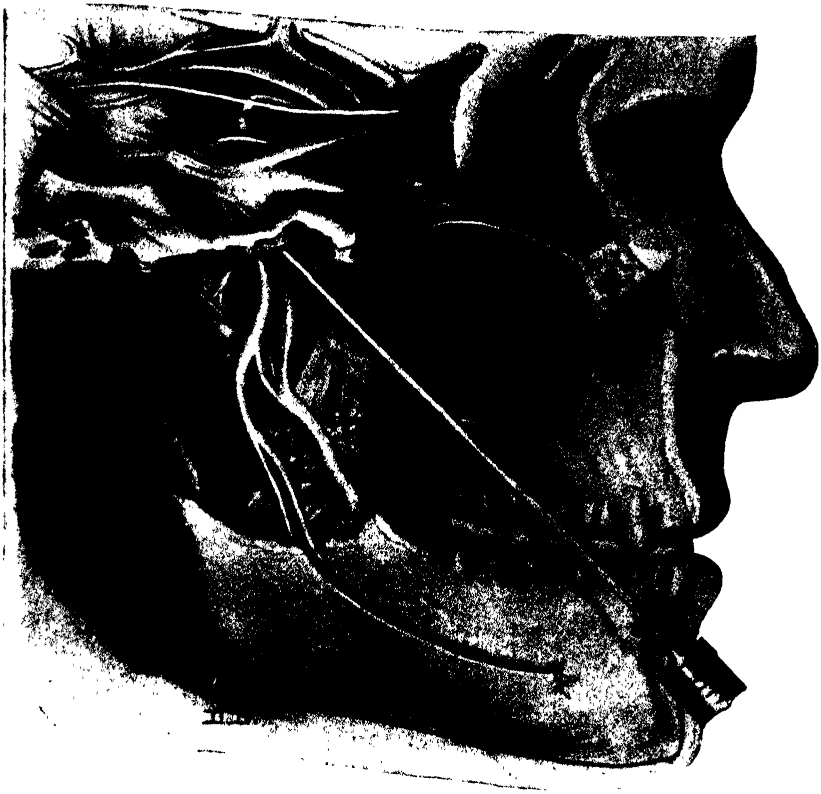

Fig. 590.—Alcohol injection of Gasserian ganglion.

Technique.—A Labat needle 10 cm. long is inserted a finger's-breadth above and behind the angle of the mouth through the novocainized skin; it can be used for anæsthetising the ganglion when the operator is sufficiently expert. Graduated needles are not so imperative as they are for the peripheral division injections. The needle is passed upwards between the maxilla on the inner side and the internal pterygoid muscle on the outer, and is directed upwards, backwards and medially to strike the external pterygoid plate. Since it is important to cause as little pain as possible, the often extremely tender bones of the base of the skull must be rendered anæsthetic with novocain. One of the most painful places is the external pterygoid plate, which must be made analgesic if the third division is to be easily distinguished. The foramen ovale lies immediately behind the point of attachment of the pterygoid plate to the base of the skull and slightly external to it. A low ridge of bone, the pterygo-spinous crest, runs from the sphenoidal spine to the pterygoid external to the foramen and, as Morris pointed out, it may rarely be high enough to prevent the needle from engaging in the foramen. The tip of the needle is coaxed over this obstruction, and should strike the third division, an occurrence which the patient will generally signalize involuntarily. In all cases aspiration should be carried out when the needle is through the foramen, because cerebro-spinal fluid may disconcertingly be obtained. The needle should then be withdrawn a little and a further test made. Two drops of 2 per cent. novocain are injected into it and the lower lip tested for anæsthesia after a minute. It is important to allow a reasonable interval for the novocain to take effect before the point of the needle is moved. If the test is positive, the needle is pushed in a further centimetre and a little more novocain introduced, but not too much, or it will dilute the alcohol and make it ineffective. The needle should not be advanced farther than one centimetre through the foramen. The face must be tested now to determine the extent of the numbness ; alcohol can then be injected without pain. On an average about 0·8 c.c. of 90 per cent. alcohol is the correct quantity. The surgeon should make this injection drop by drop, watching meanwhile for dilatation of the pupil and testing the eye movements so that he can stop at the slightest signs of ocular paralysis. It would be unwise to say that paralyses never occur, or that they are always due to glaring errors in technique. They can happen when the greatest exactitude has been observed. Fortunately they are usually transient, recovering in any time between a few hours and five months.

The result may be a complete anæsthesia of the whole trigeminal area or only a partial one. It is complete nonsense to maintain that both partial and permanent anæsthesia of any given part of the ganglion can be effected consistently at will. Study of Fig. 590 suggests that small quantities of alcohol could possibly be so placed in the ganglion as to destroy only a few cells, and this in a selective way. The effects of such minute quantities are uncertain and fugitive. In fortunate cases with slightly larger amounts the partial anæsthesia may be exactly the one required. But it may be quite the other way, with every part anæsthetic but the one needed. It is possible to get a dense anæsthesia of the first and third division with a very slight effect on the second, where the neuralgia may be worst. In that case there is nothing for it but to admit the failure and repeat the injection. It is often wise to leave the needle in place for half a hour or even an hour. In this way such anæsthesia as is due to novocaine or " shock " will pass away and a clearer evaluation can be made. Even so, the exact distribution of a partial anæsthesia cannot be determined for a few days.

Difficulties.—The chief difficulty is not being able to find the foramen ovale. Practice is the only solution. Injections should not be done by the occasional operator ; they are very difficult. It must be impressed again and again that the surgeon should not carry his search too far back—hence the skin mark. Nor must he ever inject alcohol until novocain has reassured him of the correctness of his situation. Some foramina cannot be entered because of anatomical peculiarities ; the highly skilled may surmount this difficulty by using a quite unconventional re-entry of the needle lower on the face. Failure means that the sensory root must be cut. I have had much help in difficult cases from X-raying the skull with the needle *in situ*. A basal projection gives valuable information on the position of the needle. There may be difficulty from bleeding ; the cheek and face swell (especially in those with a very high blood pressure) when the internal maxillary artery is wounded. Blood from the internal pterygoid plexus of veins may escape from the needle when the stylet is removed, but there ought to be no bleeding once the needle point has actually entered the skull. If the needle were directed too far backwards the carotid artery or jugular vein might be punctured.

Complications.—The ocular palsies are peculiar to alcohol injections. Neuro-paralytic keratitis is decidedly more common after injection and is guarded against by covering the eye with a Buller's shield for the first few days, to prevent evaporation from the eye and to exclude the air. It is wise to tell the patient to wear spectacles with protective flanges around the rim of the glass for the denervated eye, so as to prevent irritation by gusty winds and grit (which will no longer be felt). Should a progressive keratitis develop it can be absolutely stopped by tarsorrhaphy, the lids being kept closed for some months. An eye need never be lost. In patients with hyperpiesis it is quite common for a considerable hæmatoma to develop in the cheek, followed by bruising that spreads downwards. This is only a temporary embarrassment. The motor root nearly always regenerates.

THE CHOICE OF METHOD

The protagonists of the two methods have commonly denied, with a fervour reminiscent of mediæval theology, the possibilities of there being any good in the other. Both methods have their place, both have good points, and neither is perfect. The best armoured person in the treatment of neuralgia is obviously the person who can do both. The common practice amongst neuro-surgeons to-day is to perform fractional root sections for patients with tic douloureux limited to one division or two. This rule is based on the fact that it is possible to give lasting relief of pain without rendering the whole face numb, and without incurring the risks of the anæsthetic eye (unless the ophthalmic division is the only one affected, which is very uncommon). Alcohol injection is reserved for the minority who have three-division neuralgia, and for those who, by reason of other infirmities, are bad surgical risks (e.g. very high blood pressure, diabetes, cardiac, renal and bronchial invalids). Advanced age is not a contra-indication to open operation, but I prefer injection for patients over 70, except in special circumstances. I am aware that sections have been successfully carried out in persons of 80 and more years of age, and, indeed, there is no reason why a limited, largely extradural, operation should not be well borne at any age. But most will agree that a major procedure on an old person is best avoided if there is an alternative. Ganglion injections have the advantage that they give, when the anæsthesia is complete, as permanent relief as does root section, but a full anæsthesia may fade and I have seen patients come to operation who had lost an eye after injection only to have sensation and pain return two or three years later. The difficulties of obtaining a full and lasting cure by injection of the ganglion have been discussed. Matters are still more difficult when it comes to obtaining permanent anæsthesia of one or two divisions. This can only be properly achieved by operation. The great disadvantage of injection is its uncertainty, and the fact that the alcohol may do unexpected damage. No one but the most insensitive person can regard these facts with equanimity. It may be urged, and with truth, that there is no (known) mortality attached to injection whereas open operation certainly carries with it the small mortality that attaches to all surgical procedures, however trivial. None the less, the satisfaction of doing exactly what one means to do, no more and no less, under direct vision, appeals to the intelligence. It should be added that peripheral injections have a place in treatment ; they are advisable as preliminaries to give the patient an idea of what the permanent numbness will be like. There is no point in continuing with peripheral injections except in special cases, if the patient's cardio-renal system is normal, and indeed experience has shown me that patients will not tolerate this practice.

DIVISION OF THE EIGHTH AND NINTH NERVES AND OF THE TRIGEMINAL THROUGH THE POSTERIOR FOSSA

The division of the fifth, eighth, and ninth nerves through the posterior fossa can be described together ; the approach is very similar for all.

INDICATIONS

Fifth nerve.—Division of the sensory root close to the surface of the pons has been held by some (Dandy, Olivecrona) to possess advantages over the more usual section in the middle fossa (*see* p. 1239). The operation can be easier by this than by the middle fossa route ; on the other hand, veins crossing from the cerebellum to the petrosal sinus may make it much more hazardous. In general, the posterior approach will only be used when the middle fossa method has been tried already on one or two occasions by other hands without success, or in patients with malignant infiltration of the ganglion (carcinoma of the mouth, naso-pharyngeal endotheliomas) where division must be very far back and combined with section of the ninth nerve. The routine use of this approach is excellent preparation for the surgery of the acoustic neuromas. It is not without significance that the most radical operations for these tumours were first most strongly advocated by those surgeons who operate on all trigeminal neuralgias through the posterior fossa.

Eighth nerve.—There is only one indication for division of the eighth nerve : the labyrinthine crises of vertigo (so-called Menière's phenomenon). In cases which are not cured by medicinal treatment, auditory neurotomy gives excellent results.

Ninth nerve.—Glosso-pharyngeal neuralgia can be cured by division of the nerve intracranially. Avulsion in the neck gives a temporary result (1–3 years) and the pain recurs ; it should be used, therefore, only in those of advanced age. Recurrence has followed intracranial section as well, suggesting that vagal filaments may occasionally be the neuralgic mediators.

The Operation

The patient lies prone on a cerebellar head-rest, the shoulders propped in the usual way to allow free breathing. A unilateral incision is made, running up the mastoid from its tip, just within the hair-line. Reaching the superior nuchal line it turns horizontally inwards and finally slopes downwards. (Fig. 591.) The bone is drilled and freely removed laterally with the object of getting exposure as close up to the mastoid as possible. Internally, the removal goes to the midline, but it is not necessary to remove the whole of the edge of the foramen magnum as is always done in operations for tumours. An important step is the release of cerebro-spinal fluid from the cisterna magna. Bearing this in mind, the surgeon must remove just enough bone medially to allow exposure of the cistern. The cerebellum cannot properly be retracted to allow full exposure of the cerebello-pontine angle until the cerebro-spinal fluid has been drained away from the cisterna magna, so the first step is the opening of its arachnoidal veil. After all bleeding has been stopped the dura is incised and sutured to muscles below and laterally. An illuminated retractor is inserted down the lateral border of the cerebellum, the surface of which is protected from casual contusion or laceration by wet lintine strips. A de Martel retractor may be fixed in place if desired.

(*a*) **Division of the glosso-pharyngeal nerve.**—The nerve will be found rather more inferiorly than laterally. The vagal group of nerves lies very close to the auditory and facial. The cerebellum must be considerably retracted before the latter come into view. If there is any difficulty in locating the vagal group, the spinal accessory can be found as it turns up through the foramen magnum, and can be traced to the foramen lacerum posterius. There it joins the fan-shaped series of vagal roots of which the topmost is the ninth nerve. It is thicker and often a little whiter than the vagal filaments, and may be present as a double thread. Usually a tough strand of pia separates the glosso-pharyngeal from the vagal fibres, making it a simple matter to distinguish between them. In any case, the surgeon knows that the most cephalad band is the nerve that he seeks. It is picked up with a fine hook and cut. There is no bleeding.

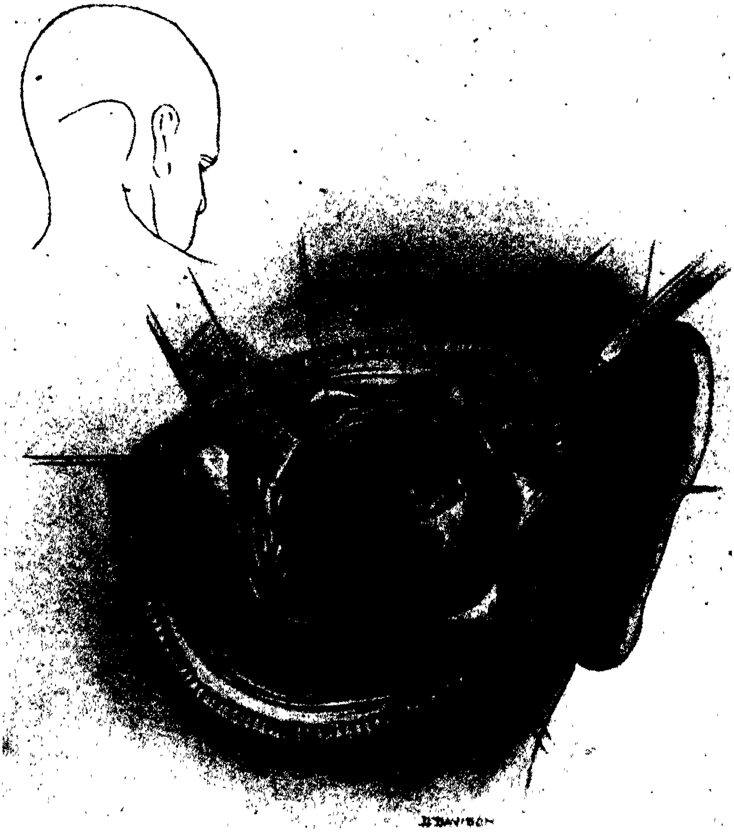

Fig. 591.—Exposure of 7th to 11th nerves in posterior fossa ; section of eighth nerve.

Division of the eighth nerve.—The approach is the same as before. Indeed, whichever of these nerves is being sought, it is certain that the others will be seen. The auditory nerve appears as a thick white band marked with a very fine single vascular stripe. The facial nerve is deep to it, and not visible until the more superficial auditory nerve has been gently and carefully lifted away from it or cut through. A fine veil of arachnoid runs off the cerebellum on to the nerve, and must be torn with a fine, long-handled, rectangular hook. Until this has been done, the cerebellum cannot be tucked back to expose more than the first two or three millimetres of the nerve. The facial and auditory are most easily separated close to their origin ; they are most intimately applied to one another where they enter the internal auditory canal. The fine right-angled hook is slipped under the auditory nerve from above and eased along it towards the porus. A curved hook cannot easily be made to do anything but pick up both facial and auditory nerves together. The whole nerve can now easily be cut on the rectangular hook. There is evidence that the vestibular fibres are cephalad to the cochlear and that section of the former alone will stop vertiginous attacks without suppressing hearing altogether. Most of these patients are very deaf already, and the final eclipse of hearing brought by complete neurotomy is no serious loss. The surgeon may feel that it is worth while to try to preserve what little hearing there is, but recurrence may follow this conservatism and in my experience complete division of the eighth nerve gives more certainty of cure than partial section. The internal auditory artery requires mention ; it often forms a loop dorsal to the nerve, but may have almost any relation to it. It is variable in size. It can always be avoided and coaxed out of the way during the essential steps in the isolation of the nerve. Vascular anomalies have been suggested as the cause of vertigo, but such evidence as there is favours a peripheral (labyrinthine) cause for the vertiginous attacks (Hallpike and Cairns). The dura is closed to prevent oozing from the muscles entering the posterior fossa.

Division of the sensory root of trigeminus.—The approach is the same, but the nerve lies considerably deeper. The operation is neat, quick, and often very easy. The occipital bone opening may well be made a little fuller, especially upwards. The cerebellum is retracted as before, after releasing cerebro-spinal fluid from the cistern, and the seventh and eighth nerves identified. A narrow retractor is slipped in between these nerves and the tentorium. The first difficulty may be met in the attempt to do this ; the impediment is a vein crossing from the cerebellum to the junction of the superior petrosal with the lateral sinus in the angle. It may or may not be present. It must be looked for, coagulated and divided, for if it is accidentally torn much time will have to be spent in controlling the bleeding. A small muscle graft may be placed over the dural end of the vessel if it should continue to bleed ; coagulation on the bone is useless. If this vein is not present, or after its division, the cerebellum can be nicely retracted. Since the sensory root emerges from the pons, the retractor must gently be insinuated deeply. Good illumination is necessary, a good headlight, and a suitable retractor. Two centimetres medial and superior to the auditory nerve the thick white band which is the trigeminal root will be made out. (Fig. 592.) Veins always pass forwards from the cerebellum to the inner end of the superior petrosal sinus close to this root. On rare occasions they obscure it; if so they must be coagulated, but it is best to try to hook the root down or away from them. A bad venous hæmorrhage in this situation might well mean an end to the operation (and possibly to the patient). If the root can be reached but not separated from the veins, it will suffice if a silver clip is firmly applied to the root and vein as well (Olivecrona). A special long clip-forceps (Stille pattern) is needed for this, and indeed the operation should not be done without it. The fibres of the trigeminal root can easily be distinguished; they run more directly forwards than any other visible nerve in the posterior fossa. Further, the trigeminal is a very large nerve and easily identifiable on this ground alone. It can be torn through or cut, wholly or in part. The motor fibres are not easily included in such a division, for they form a separate fascicle slightly medial to the sensory fibres. The deepest of these latter are those of the ophthalmic division and will best be left uncut for the average case. It is said to be possible to stop neuralgic pains without producing deep anæsthesia of the face if only half to two-thirds of the sensory root is divided. This is true of section in the middle fossa also, but by neither approach is it constant. Probably neuro-paralytic keratitis is rarer than after neurectomy through the middle fossa. The only disadvantage is that inadvertently-caused venous hæmorrhage from one of the large vessels, especially the deeper ones, may lead to frank disaster. I have not personally met with such a happening, but it is known to have occurred. Care must be taken not to overstretch or bruise the seventh and eighth nerves during the approach. They might be injured if any sudden hæmorrhage occurred and packs were inserted without thought for other possible damage. It need hardly be said that perfect anæsthesia is necessary for these lateral recess operations. If the cerebellum is blown up tight by congestion, so that it cannot be delicately drawn on one side, the operation should be abandoned for the day.

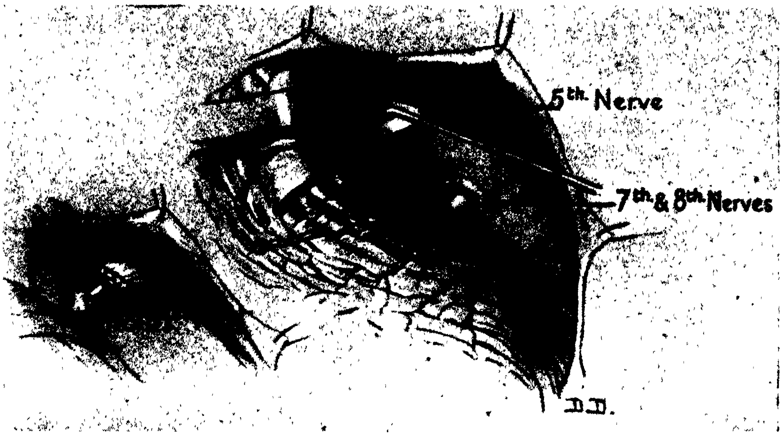

Fig. 592.—Division of trigeminal root by approach through posterior fossa.

Should the dura be closed or left open? If the cerebellum has been badly bruised (it ought not to have been) it will be best to leave the dura open to allow for post-operative œdema. If there has been much bleeding from the muscles and if the cerebellum looks very neat, it is well to suture the dura to prevent oozing into the posterior fossa.

For the technique of tractotomy, the division of the fibres of the trigeminal root in the medulla, which interrupts pain impulses, leaving touch practically unimpaired, the reader is referred to papers of O. Sjöqvist, the inventor, G. F. Rowbotham and F. C. Grant.*

INTRACRANIAL ANEURYSMS

The intracranial aneurysms requiring surgical consideration are most often extracerebral. Those of the posterior part of the circle of Willis are inaccessible, but if they spring from the internal carotid, either before it pierces the dura (infraclinoid) or immediately afterwards (supraclinoid), intervention is possible. The indications for operation are two: (*a*) if a saccular aneurysm produces focal signs; (*b*) if the aneurysm leaks, giving rise to subarachnoid hæmorrhage; but some focal sign is necessary to indicate with precision the site of the aneurysm (a condition not always fulfilled).

(*a*) **The infraclinoid saccular aneurysms of the internal carotid** in the intracavernous part of its course are best treated by ligature of the artery in the neck. There is little risk of hemiplegia in such cases; cerebral anoxia and resulting paralysis are due usually to (*a*) general impairment of cerebral circulation, which is made worse by anything causing a rise in intracranial pressure (*e.g.*, if an aneurysm has leaked recently); (*b*) compression of an important collateral by the aneurysmal sac; (*c*) low systemic blood pressure arising from ill-health or external bleeding. Contrary to current belief, neither primary cerebral thrombosis nor retrograde embolism from the site of the ligature is the cause; nor is a congenital deficiency of the circle of Willis (Schorstein, 1940).

(*b*) When the aneurysm arises from the **trunk of the artery** just after it has pierced the dura (*i.e.*, from its short supraclinoid portion just before it divides) a direct attack on the aneurysm is better surgery than carotid ligature, since all three of the factors contributory to disaster after ligature may be present. Experience has shown that an isolated unilateral third nerve palsy is a characteristic sign of aneurysm at this site. Even so, it is wise to make angiograms to confirm the site and to discover the size of the aneurysm. (Fig. 593.) The palsy may or may not be associated with subarachnoid hæmorrhage; in either case operation is indicated.

Operation.—The approach is as for a pituitary adenoma until the optic nerve is seen. (Fig. 593, c.) Instead of working to its medial side, attention is directed to the carotid artery on the lateral aspect of the optic nerve and chiasma. The arachnoid is dissected away until the arterial trunk can be seen and followed up in the search for the aneurysm which lies posterolaterally to it. Good retraction without damaging the brain is essential. The dura covering the cavernous sinus comes into view and the sac is isolated and its neck closed with a silver clip if its narrowness and the lie of the aneurysm allow of this. (Fig. 593, d.) Usually this is so (*see* my records and those of Dandy, who first suggested this method) ; if not, it is probably better to pack muscle around the sac on all sides (Dott).

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* Sjöqvist, O., 1938, *Acta Psych. et Neurol.*, Supplement, 17. Rowbotham, Brit. Med. Journ., 1938, ii, 1073. Grant, F. C., Croft R. A., and Lewy, F. H., *Arch. Neurol. Psych.* 1940, xliii, 498.

When ligature of the internal carotid has failed to cure a carotico-cavernous fistulous aneurysm (with pulsating exophthalmos) Dandy, to stop the down flow from the circulus Willisii, has clipped the internal carotid artery itself immediately after it has penetrated the dura.

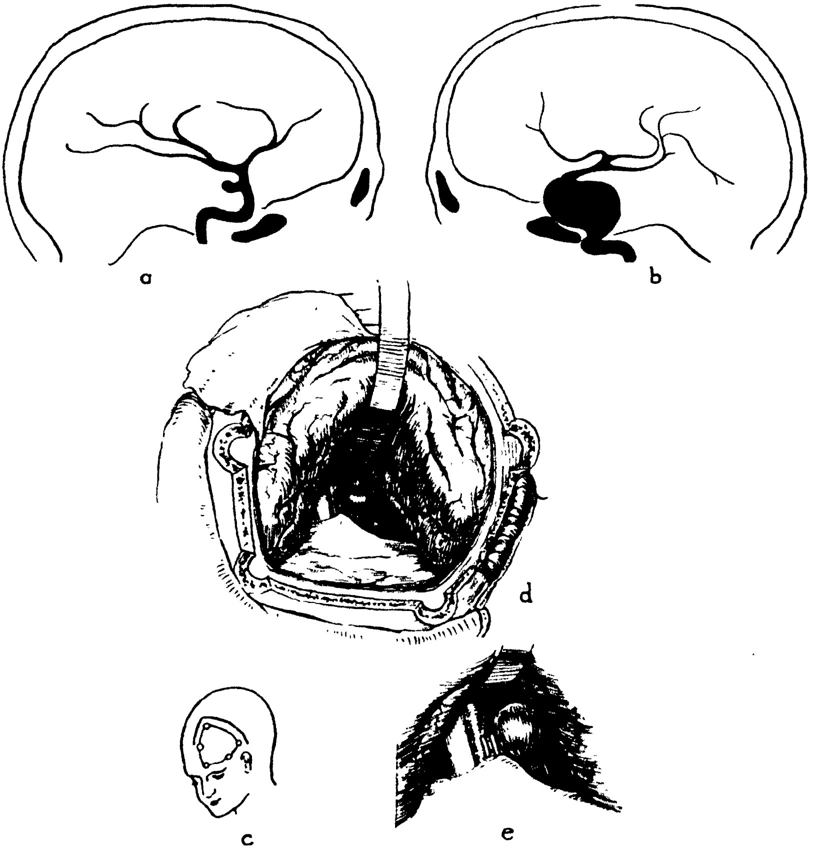

Fig. 593.—Exposure of supraclinoid carotid aneurysm.

a, angiogram of supraclinoid aneurysm. **b**, angiogram of infraclinoid aneurysm. **c**, skin incision. **d**, supraclinoid aneurysm exposed. **e**, silver clip applied to aneurysmal neck.

THE SURGERY OF CRANIO-CEREBRAL TRAUMA

The interpretation of the neurological phenomena of head injuries, of concussion and contusion, has varied from time to time as now one, now another, philosophical dogma has had its day. Operative treatment has been favoured, discredited, and popularized again ; each alteration has marked an important forward step, paradoxical though that may sound. In general, the treatment of the contused brain remains a non-operative one, but we are increasingly ready to intervene. We reserve active treatment of one kind or another for the "epiphenomena" of head injury : extra- and intra-dural hæmorrhages, œdema and infection. When, therefore, we say that the treatment of head injuries is largely conservative, we mean that it consists in the cultured withholding of possible operative steps unless developments prove their need. Besides these intradural indications for operation, another important one may be found in the state of the skull itself ; open fractures always demand intervention. It is beyond the scope of this book to discuss the management of head injuries, or to give advice on the treatment of cerebral œdema, meningitis or on the basic state of contusion itself. We pass to an account of the operations necessary for the repair of local injury and the control of bleeding.

Open Depressed Fractures

Whenever the exploration of a scalp wound reveals a depressed fracture operation must be performed at once. There are no exceptions to this rule ; only a *closed* depressed fracture can often be left alone. Open injuries vary greatly in severity. In some there is merely a pond or stellate depression of no great size. In others, part of the frontal, of the squamous temporal, or of the parietal bone may be driven through the dura so that the brain matter exudes. Although the local injury may be alarming, consciousness may be retained, for that is not the function of any localized portion of the cortex or of the frontal lobes. Circumscribed damage is therefore quite consistent with relative alertness on the part of the patient. Operation must not be postponed because the injury is either slight or formidable ; when a compound fracture is present delay means the conversion of a contaminated wound into a grossly infected one. Profound unconsciousness is a legitimate cause for hesitation, because it indicates wide injury to the brain base and stem in addition to the superficial injury that can be seen.

Technique.—No detailed description will be given of the method of excising scalp wounds, but it is impossible to over-emphasize the necessity for thorough cleansing and careful excision of all scalp wounds. In what follows it will be assumed, therefore, that the surgeon fully understands his responsibility for dealing adequately with the overlying soft-part injury.

It is best to gain exposure, after complete cleansing and sparing excision of the wound edges, by prolonging its limbs until the fracture can be clearly seen ; if its ramifications are still obscured the incision should be extended. It is common for the edges of the depressed bone to be jammed together so firmly that they are immovable. Sometimes fragments of dirt and scalp can be seen wedged in the cracks. A drill-hole is made or trephine disc removed over firm bone at the edge of the depression. With a pair of narrow-pointed nibbling forceps, the skull at the edge of the injured area is removed to the impacted fragments. If they are seized and rocked out before they are loosened there is considerable risk that the dura will be lacerated, or, if it is already injured, that more and deeper damage will be inflicted on the brain. With the proper forceps, the bone fragments may be carefully cut in such a way that they release themselves. The necessary steps suggest themselves to the operator as he inspects the actual wound. It is bad practice greatly to enlarge the bone defect, though there is no harm in trimming its edges neatly. It must be remembered that the larger the hole in the bone the more impressed will the patient be afterwards by the severity of his injury (unless it has been brought about by his own negligence or by a sporting accident). The loosened bone having been lifted out, the dura is washed over thoroughly with saline. If it is intact, so much the better ; if it must be opened to liberate clot it must be resutured, for it is a vitally important protective barrier. If the membrane has been lacerated, brain oozes out and has probably been doing so already. Pulped cerebral tissue should be allowed to extrude under a stream of warm saline and removed by gentle suction ; the surgeon must make sure that no indriven bone fragments are hidden in the injured brain, though this is only common in gun-shot wounds. Any that have been seen in the X-ray film must be retrieved. The best way to ensure a clean wound is by judicious use of suction. If there is a deep track it should be dealt with in the same way. (Fig. 594, and see later.) The dural edges should not be

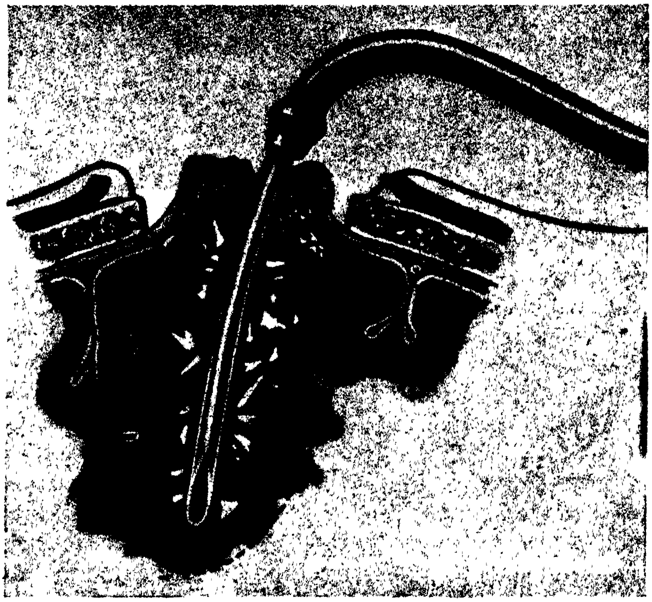

Fig. 594.—Suction extraction.
The dotted line shows the area to be sucked out.

interfered with nor the membrane excised, because this opens up the lepto-meninges to infection. The operation is completed by suture of the wound, leaving a drain through the posterior and most dependent limb of the incision. The bone fragments must not be replaced because they are potentially infected.

Closed Depressed Fractures

The fashion for elevating all depressed fractures beneath an intact scalp is on the wane. It is certain that a moderate depression does no harm, and that there is little risk of epilepsy developing later from the supposed pressure of the bone (*see* p. 1274). Such damage to the brain as may sometimes be present is always produced at the moment of the accident and is not made worse by the depressed bone. On the other hand, it is not always easy to be satisfied that the dura has not been torn or the cortex lacerated. A fair estimate of the probabilities can be gained only from the study of radiographs—especially of oblique, tangential views—and from the neurological examination. If it is then observed that bone is severely depressed, that the fragments are acutely angulated, or so far indriven that the dura can scarcely have remained uninjured, or if there are focal signs, it is wiser to operate. The operative steps are similar to those enumerated above, with this important difference : that each fragment of bone should be carefully preserved, washed in saline or Ringer's solution, and replaced. This is an entirely permissible and worth-while step if the technique has been rigidly aseptic. Replacement of the bone answers the objection that operation on depressed fractures in industrial accidents only too often leaves the patient with a more abnormal skull than before, and that the sufferer may then develop an anxiety neurosis which is well-nigh incurable. The replaced bone restores a good contour to the skull. It is better to make a horse-shoe incision for these depressions and to close the wound firmly in layers without drainage. The operative field should be inspected daily for the first four days, and clot either aspirated or pressed out, after insinuating the flat end of a probe through some convenient point in the incision.

Depressed Fractures in Infancy

These form a special group, and are always very alarming to the parents because they so commonly arise through some momentary negligence, real or imagined, of the parent or nurse. The great elasticity of the infant's skull causes it to indent very readily, often with scarcely an abrasion on the overlying skin. Sometimes the depression is shallow and may then be left to take care of itself ; remarkable remodelling of contour can take place within a couple of years. When the depression is sharply incurved the whole area should be cut and reversed. The operation can be performed under local anæsthesia (0·5 per cent. novocain with a minute quantity of adrenalin), if the baby is given a bottle feed as soon as the drapes have been applied. Through a curved incision the bone is cut through on the edge of the pond with a small sharp mastoid gouge ; carefully and obliquely applied there is no risk of wounding the dura. Through this opening the dura is loosened, one blade of a pair of strong narrow-bladed blunt-nosed scissors inserted, the depression encircled, freed, reversed and replaced.

GUN-SHOT WOUNDS OF THE HEAD

In warfare an attempt will be made to segregate these injuries in special hospitals where they can be operated upon and looked after by teams supervised, at least, by those with neuro-surgical experience. None the less, a number will have to be dealt with by others, with nothing but mother wit and surgical first principles to help them. Apparently simple scalp wounds must be regarded with greater suspicion than those seen in civil life, for the chances are great that there has been splintering of the skull or penetration by small fragments of metal. No greater mistake could be made than to regard the surface injury as the only problem. Competent X-ray and pre-operative neurological examinations are indispensable for intelligent surgery. Often enough, some alteration in the power of a limb, or in the reflexes, indicates that the wound is not as innocent as it appears. Operation is always necessary for gun-shot wounds, and follows the general rules applicable to all injuries of this type. It must be undertaken fairly early, because such wounds are always contaminated, though often not so heavily as those of the limbs. The patients should first be resuscitated, the less severely injured being operated on first. Those who remain deeply unconscious have deep damage, and will probably die in any event. The object to be attained is complete mechanical cleansing from all devitalized tissue, converting the open injury into a closed one with as little likelihood of subsequent infection as possible. The best anæsthetic is 1 per cent. novocain-adrenalin. If the patient is restless he should be given evipan or pentothal. Instructions on the positioning of the patient, on care for his comfort, for provision of a free air-way, and the arrangement of drapes has already been given on p. 1190. The best types of incision are shown in Figs. 595 and 596. The triradiate incision introduced by Harvey Cushing has many advantages.

Treatment of the bone.—Gutter wounds in the bone are opened up by nibbling the contused bone away all around, until healthy dura forms a fringe half an inch wide about the central perforation. There may be difficulty in removing the bone at the edge of a gutter without biting away pieces of dura as well. This dangerous mishap can only be avoided by making a drill hole in the bone so that the dura can be clearly seen and separated from the inner table. The drill is greatly superior to the trephine ; it is much quicker and less tiring—a very important consideration in military work, where large, not to say overwhelming, numbers of cases may have to be dealt with. Recently, the cutting of bone flaps has been advocated to allow more complete inspection and cleansing by suction. Provided that the wound is recent and that the number of cases dealt with is not too great, the bone flap has much to commend it.

The dura and brain.—When the bone has been removed, the dura is inspected. If it is intact, it is only opened if there are positive neurological signs, but more especially if the dura looks very dark, for that indicates blood beneath it. If it is deliberately incised, it must be closed again carefully. When the dura is torn, loose pieces of bone just below the surface are picked out with forceps and the wound washed over with saline. The pulsations of the brain cause an efflux of semi-liquid cerebral tissue which can be aided by coughing. As it

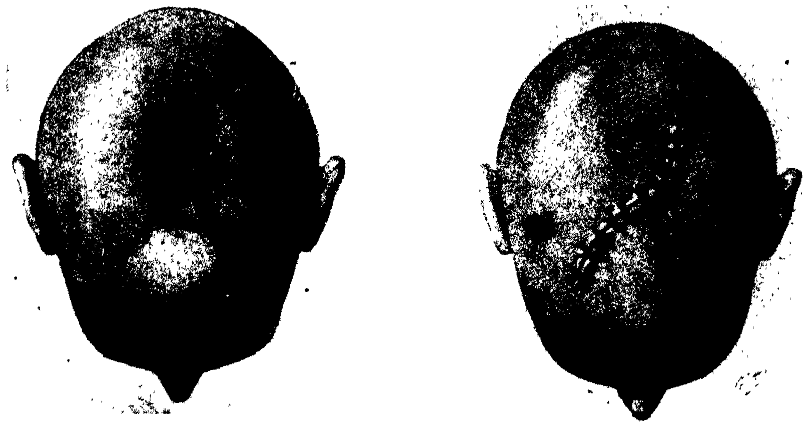

Fig. 595.—Plastic operation on scalp : tripod incision.

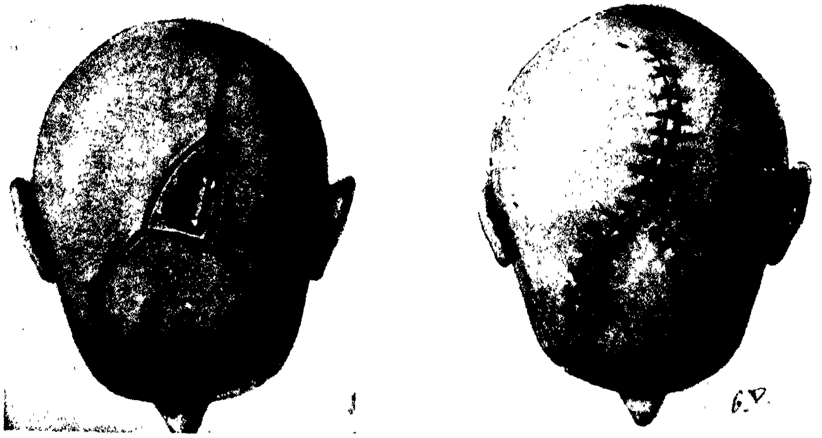

Fig. 596.—Plastic operation on scalp: tripod incision.

exudes, it may bring out with it further splinters of bone. All devitalized brain is sucked out until healthy undamaged tissue is visible all around; a clean cone will be left. Naturally the situation of the wound may limit the thoroughness with which this can be done (e.g., motor cortex). Suction should be adjusted in power to remove pulped tissue but not to lift the only slightly tougher normal white matter. During this sucker removal bone fragments are discovered and removed with fine crocodile forceps. The position of indriven bone fragments, as well as of any missile, must be carefully noted on pre-operative X-rays; the number of foreign bodies must be counted and checked as the operation proceeds. Finger exploration should never be used. The only objects that travel great distances into the skull are missiles; they may of course traverse right through without killing. The search for and extraction of a deeply placed piece of metal should be undertaken only by the very competent, armed with an electro-magnet. Whether there is an electro-magnet or not, a very deep missile is usually best left alone; often it does no harm. Shell fragments rarely weigh more than 10 grams or so; very large ones kill the patient outright.

The closure of these scalp wounds is more difficult than in civilian types, for there is more loss of tissue, and scalp is inelastic. Closure can be brought about by extending the limbs of the incision at such angles as will allow dissecting-up of flaps. Sometimes flaps of scalp can be swung across, but plastic flaps, though they look well in textbooks of surgery, can rarely be successfully used. There is no great harm in leaving the wound slightly open, nor in drainage with a strip of rubber. Indeed, firm closure is unwise unless a perfect excision has been possible on a clean and very recent wound. Should the wound be already septic, say, after 4 or 5 days, it should be opened up, bone fragments removed, necrotic brain sucked out and the scalp sutured, leaving the wound slightly open.

INTRACRANIAL HÆMORRHAGE

There are few clinical syndromes so well known and so well taught as the classical syndromes of middle meningeal hæmorrhage, and surely there is none which is so rarely seen in its perfect form. Both extradural and intradural hæmorrhage have been recognized since craniocerebral injuries were first observed. The dangers of the former have made a much deeper impression on surgical practice than the latter. During the last fifteen years the frequency with which the subacute and chronic subdural hæmatoma has been found and successfully dealt with by the neuro-surgeon demonstrates the necessity for a new orientation. Its operative handling is simple, and no doubt the simplicity of the operative steps has been an encouragement in that it has led to the discovery of clots that were suspected rather than firmly deduced from a train of classical symptoms and signs. Indeed, it is well to operate on suspicion for both kinds of hæmorrhage. The results, whether the clot be epi- or intra-dural, depend: (1) on the rapidity with which the clot is discovered, and (2) on the extent of coincident contusion to other parts of the brain. The recovery rate in middle meningeal hæmorrhage is low, a fact attributable unfortunately more often to failure in diagnosis than to severe concomitant cerebral contusion. Those cases do best in which the clots are of sufficiently slow evolution and in which the injury to the brain is insignificant. Better results are obtained from the chronic subdural hæmatomas, those giving rise to symptoms some weeks or months after an injury.

OPERATION FOR EXTRADURAL (MIDDLE MENINGEAL) HÆMORRHAGE

The operation for extradural bleeding is carried out as for intermusculo-temporal decompression. There are two chief objects in this operation: (1) to remove the clot; (2) to prevent its recurrence by securing the bleeding vessel. The first presents no great difficulty, the second can be very hard. The size of the clot depends on the degree of adhesion of the dura. Experience in stripping the dura in the middle fossa during operations for trigeminal neuralgia leads to the conviction that some individuals must be immune from this type of lesion on account of the closeness of the dural adhesion to the skull, but that in others a potential cavity, into which bleeding can occur, must be formed by the local loosening of the dura during deformation of the skull at the moment of injury. When the hæmorrhage is purely arterial there is little difficulty in arresting it but, as Wood Jones thought probable years ago, in many cases there is venous bleeding as well. These are the difficult cases technically. What happens is that the arterial extravasation increases the potential cavity and, as it strips the dura from the bone, it sets off the same venous bleedings that are encountered by the surgeon when elevating the dura from the floor of the middle fossa during the approach to the Gasserian ganglion. It comes from four sources: (*a*) the middle meningeal vein; (*b*) the spheno-parietal sinus anteriorly; (*c*) the superior petrosal sinus; and (*d*), though very rarely, the cavernous sinus. The control of this bleeding is not the simple matter that text-book descriptions have usually implied.

Technique.—If the patient allows his head to be prepared without violent struggling, this should be done before he is brought to the theatre. If not, the hair is clipped as short as possible and the final shaving done on the table. Under ether, or local anæsthesia and evipan, a vertical incision over the temporalis muscle is marked by a scratch before the drapes are applied. It runs upwards over the temporal fossa from the zygoma below, for a distance of three to four inches, and is placed half way between the tragus and the external angular process. The skin incision having been made with the usual precautions against unnecessary blood loss, the temporal fascia is cut through and the muscle split to the bone, of which as large an area as possible is bared with a raspatory without pulling the temporalis away from its superior attachment. A self-retaining retractor is now inserted and an opening made in the bone in the usual manner. As soon as this has been done the characteristic dark red clot is at once seen, with something more than a trickle of fresh bleeding oozing from around and amongst it. The bone is nibbled away to make an opening some 2 in. in diameter; especially must the bone be taken away downwards. The clot is removed with a spoon and gauze until the stained dura, to which small pieces of clot are always firmly attached, comes into view.

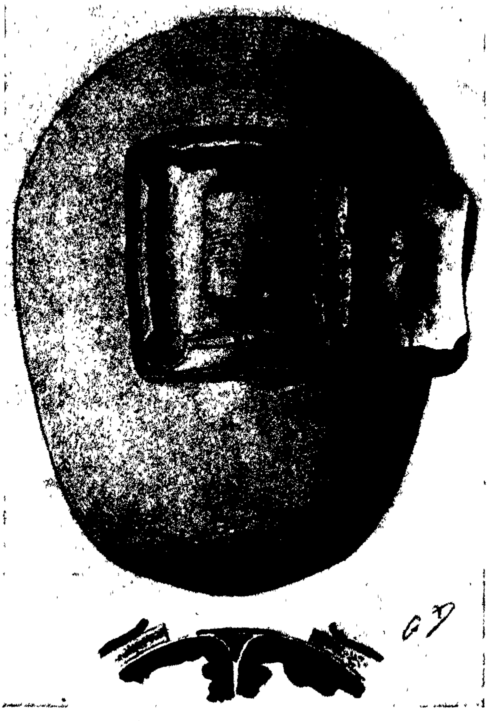

Fig. 597.—Application of "postage-stamp" graft to superior longitudinal sinus. Exposure of injured area by osteoplastic resection.

It cannot be too strongly emphasized that decompression of the clot by removal of the temporal bone is insufficient. Cases are known where death from middle meningeal bleeding has followed an operation for trigeminal neuralgia. This shows clearly that the presence of an operative bone defect will not save the patient unless all bleeding points are secured. The next step is to ligature the middle meningeal artery proximal to its rupture. This is most easily done by endotherm coagulation, but if that is not available the vessel must be encircled with a suture of silk on a very small needle, such as the Lane's cleft palate type; larger needles cannot be manipulated in the cramped space. It may be necessary to remove more bone to obtain enough room. If the bleeding is purely arterial, that is the end of the operation, apart from wound closure, but if, as is often the case, there are venous points still to be attended to, these must be identified. Constantly washing out the wound and the use of suction under excellent illumination allow identification of the places to which muscle grafts should be applied. (Fig. 597.) A considerable amount of the temporal muscle may have to be removed to make these grafts, or muscle must be taken from the leg. It is better to do this than to pack the wound with gauze. All the steps of the operation are easier if it is done with the patient in the sitting position. The wound is closed in layers with a small rubber drain which is left in for 24 hours.

K. Mackenzie has very properly advised making a second burr hole posteriorly if the caudal margin of the clot cavity cannot be reached. Not only may there be dural bleeding in a part of the field which is otherwise not in view, but this clot may be both thick and extensive and may even (rarely) descend over the cerebellum.

OPERATION FOR SUBDURAL BLEEDING

The subdural hæmatoma occurs in a subacute and chronic form.

Subacute subdural hæmatoma.—This type is commonly mistaken for middle meningeal hæmorrhage and, indeed, it may not be possible to distinguish them. In such cases the operation will follow the lines already laid down for extradural bleeding ; but, no clot being visible outside the dura, this must be opened as widely as the bone deficiency allows, and the blood evacuated. If, even after opening the dura, no hæmatoma is seen, then burr holes must be made on the other side, or as below, for lateralizing neurological signs may be unreliable.

Chronic subdural hæmatoma.—The correct method of operating for this condition is the four burr-hole method. (Fig. 598.) The holes are made under local anæsthesia just above the lambda and at the coronal suture, two on each side, and 3 to 4 cm. from the midline, which must be marked out clearly with iodine. The sites of the exploratory holes are scratched before the towels are applied. As soon as the dura is exposed the surgeon can judge whether blood is present beneath. If there is a subdural clot the dura is dark and even greenish ; if there is no clot it is pinkish-grey. The dura is now incised ; and the fine cellular membrane which encloses the clot is scratched through, whereupon its usually remarkably fluid contents run out. Curiously, these are never high-pressure cases ; the clot does not spurt out under tension. It is possible gently to wash out the cavity with Ringer's solution or normal saline from one hole to the other (on the same side). Even if a clot is found on one side, an exploratory puncture must always be made on the other, for bilateral effusions are common. Most of them are found through the anterior burr hole, but they may be encountered in the process of making the posterior burr holes for ventriculograms on individuals

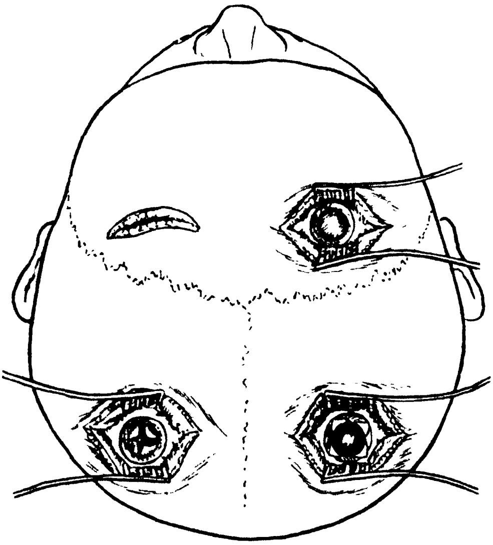

Fig. 598.—The four burr-hole method.

with signs supposedly due to tumour. The operation completed, all care is not yet over. Even if a drainage tube is left in (and it is well to leave one), a ventricular puncture needle must be inserted periodically, for the extravasation is rarely completely disposed of at once. The troublesome reformation of subdural clots may necessitate turning a bone flap and peeling the whole clot, with the membrane which so constantly encloses it, off the cortex. This procedure should be avoided if possible, for it is better to keep the skull as a closed box. If a flap is turned, the dura only too often bleeds post-operatively and the condition is as bad or worse than before. It is therefore best to reserve the osteoplastic flap for the rarer cases in which the clot is solid.

THE SURGERY OF INTRACRANIAL ABSCESS

The pathology, the behaviour characteristics and the response to treatment of intracranial abscesses have been greatly clarified during recent years. The access of knowledge has been reflected in their surgical management, for we have come to understand that only the subacute and chronic kinds are really amenable to treatment. The acute form is nothing else but an acute phlegmon with a necrotic, purulent centre. If improvements in the therapy of this last come about they will derive more probably from chemotherapeutic measures than from newly-devised manipulative steps. Knowing that some measure of encapsulation must be arrived at before we can look forward with any confidence to the drainage of an abscess, there is no longer a rush to intervene at the earliest possible moment, but rather the reverse—a tendency to wait as long as possible before drainage is instituted. The brain, like the peritoneum, has considerable power to localize an infection, a power on which we can justifiably rely unless it is conquered by overwhelming bacterial invasion. The patient's state may not allow delay, but if so, the result of an operation will probably be disappointing unless the abscess has been latent for some time, so that it is in reality chronic, though the history is short (p. 1272).

Brain abscesses are due either (1) to spread of an infection from the contiguous bone, and especially from the mastoid and paranasal air sinuses ; (2) embolism from infection in the lung, pleura, tooth sockets, from furuncles and so forth ; (3) abscesses which may form, early or late, in the tracks of penetrating wounds, especially when these have not been thoroughly rid of indriven foreign materials (bone splinters, cloth and, more rarely, metallic fragments). To the first group belong the common examples where the septic process spreads either from adhesion of the adjacent lepto-meninges and cortex to the pachymeninx over the infected bone, or by septic thrombo-phlebitis traversing from dura to brain. Here belong the abscesses complicating mastoid disease, empyema of the frontal and ethmoid sinuses, and osteomyelitis of the skull. In the second large group, the embolic, the abscess is curiously often single and not infrequently subacute or chronic, except when it arises from the lung, when it seems to be uniformly unencapsulated and fatal.

The most that can be done for the acute abscess is to make a burr-hole puncture and aspirate the purulent centre of the infected region. The introduction of a drainage tube into a diffuse area of sepsis makes matters worse, and indeed, when the surgeon punctures an acute abscess, he does so, not in the knowledge that he is doing good, but in the hope that the abscess is not so acute as the history suggests. For it is quite certain that in many of the cases where signs of an abscess force themselves into recognition after an operation for chronic mastoid disease, pus has often been present for some time. Indeed, an intradural abscess may have been the real and undiscovered reason for which the patient sought treatment ; the pain and malaise of the early stages of the formation of a cerebral abscess can easily be misinterpreted if there is an external focus which seems to explain the symptoms. Thus it comes about that an encapsulated abscess with a recognizable wall is not uncommonly found only a few days after an operation on the ear. F. C. Grant's experimental work shows that five or six weeks are necessary for the development of a considerable capsule. Given a certainly acute air-sinus infection (which, incidentally, more often induces meningitis than abscess) the best method is to handle the external condition operatively and to treat the complications by the oral or intravenous administration of bactericides.

Given a subacute or chronic abscess I have, like others, found great virtue in boring a hole over its suspected site, puncturing it, and injecting 2 c.c. of thorotrast. X-ray films will then give very complete information of the size, shape, position and relations of the abscess, and the surgeon can undertake drainage or enucleation with great confidence.

DRAINAGE OF SUBACUTE AND CHRONIC ABSCESSES

(a) **Temporo-sphenoidal.**—The best method of treatment is marsupialization of the abscess (Cushing-Horrax, Fig. 599). Whether that can be done or not depends on the toughness of the wall and the nearness of the abscess to the surface. If the capsule is not strong enough to hold sutures it must be drained, as described below, without anchorage. In either case the operative steps, down to the exposure of the abscess wall, are the same.* If the original septic condition of the middle ear and mastoid has not been dealt with, it should be treated at the same time. Team work between the otological and neurosurgical service is of the greatest value. The otologist has been accustomed to drain these abscesses from below through the tegmen tympani, but there is no advantage in doing this, rather the reverse. A better method is to carry out the necessary steps on the mastoid, and to pack the wound temporarily with flavined gauze, then make a vertical extension, two inches long, upwards from the top of the post-auricular incision, opposite the external auditory meatus. This cut is carried to the bone through the temporal muscles, the fan of which is thin in this posterior situation. The muscle is cleared from the bone to expose an area 4 cm. across, and a self-retaining retractor is inserted. A burr-hole is made in the exposed temporal squame which is nibbled away to the full extent of the exposure and down to the floor of the skull. The next step is to verify the presence of the intradural abscess and to discover whether the exposure is the best that can be obtained for its drainage. An opening, just large enough to allow the unimpeded passage of a blunt-nose ventricular cannula, is made in the dura. The cannula is introduced very slowly and gently until it comes in contact with the rubber-like resistance of the abscess wall. There it is stopped and withdrawn after marking the depth. If the measurement is over 2 cm., the cannula is reintroduced more obliquely to discover whether the abscess comes nearer to the surface at another place. The opening in the bone may require enlargement, since the surgeon can never be certain beforehand that it will be placed in exactly the right position. If he wishes to make certain that he has really found the abscess he punctures it, but he must not permit the escape of more than a few drops of pus. If the abscess collapses, the next and vitally important steps in the procedure will be made more difficult than they should be. Having satisfied himself that he has obtained the best approach, he opens the dura with a cruciate incision to the limits of the osseous defect.

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* There is a tendency to cut bone flaps for all abscesses, but although this is a good procedure it is not yet clearly proven that it is superior in its results to the method here described.

The brain bulges into the wound and occludes the meningeal spaces. The next step is the excision of the cortex overlying the abscess. The vessels are secured by coagulation, with silver clips, or by underrunning them with the finest silk and tying them off. A disc of cortex some 3.5 cm. across is then cut out ; in this process a deep but small artery or two will probably have to be secured. It is unsafe to carry out the " uncapping " of the abscess wholly with the knife. It is better to change over to a blunter instrument and dissect the subcortical tissues off the abscess capsule with that. The end of a narrow brain retractor serves very well. The abscess wall is easily recognized by its pinkish colour. An attempt is next made to insert four sutures of fine silk into it (see Fig. 599). If they hold, the abscess can be properly marsupialized by sewing it to the deepest fibres of the temporal muscle or to the galea. If they cut out, the abscess must be drained where it lies. If the capsule has proved sufficiently tough to take stitches, the abscess is next punctured and 5 c.c. of pus aspirated, but it should not be completely deflated until a circular piece has been cut out to take the drain. Retractors are slipped into the cavity through this hole and its interior dried out under vision, and finally wiped over with thorotrast. This radio-opaque substance is most valuable because radiographs taken from time to time afterwards keep the surgeon informed of the shrinkage of the abscess wall. A rubber drainage tube of 1 cm. bore is left in and the wound pulled together with sutures.

Recovery after marsupialization is the rule. When it is not practicable, the results are still very good if the abscess can be exposed in the manner described and drained without anchorage. The uncapping of the abscess, the excision of a disc from its wall, the inspection of its interior and the insertion of the drain, all under direct vision, are the marks of the modern operation with its greatly improved results. Compare with this the alternative method of blind puncture of the abscess, the attempt to introduce a drain into a collapsed sac through traumatized and œdematous cerebral tissue, the fumblings in the dark, the uncertainty whether the tube was really in the abscess or lying against its outer wall, more plunges with the sinus forceps which might this time penetrate both the inner and outer sides of the capsule, a last dubious insertion of the tube—and the choice of procedure is not in doubt. Since the drainage-tube must be left in for at least a month, it is as well not to push the tube in as far as it will go; so long a tube will delay healing. Half-way is far enough. There may be difficulty in fixing the tube, in view of the long time that it must stay. The best method is to suture it to a piece of elastoplast fastened across the wound. Adson and King advocated the introduction of

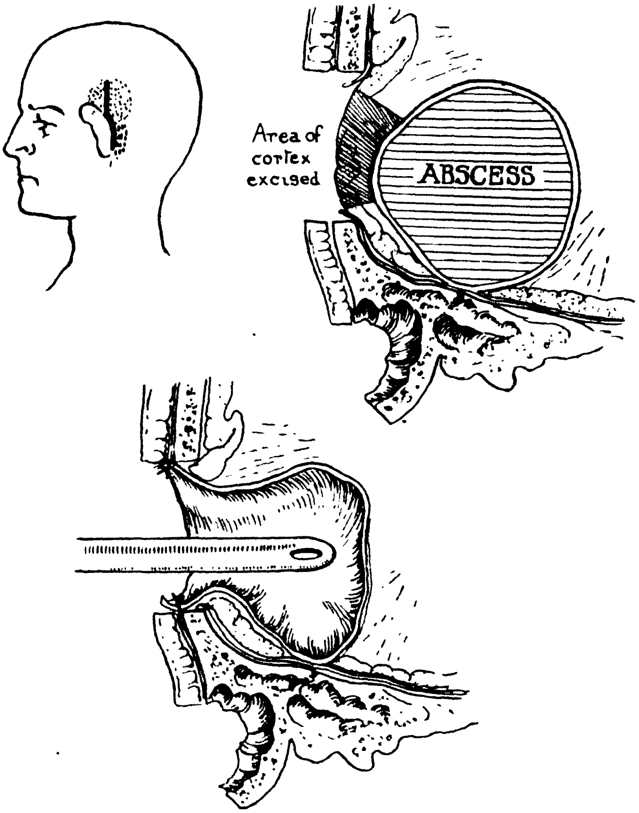


Fig. 599.—Drainage of temporo-sphenoidal abscess by marsupialization.

gauze strips as well as the tube, to be removed, one by one, over a period of ten days; it is doubtful whether there is any special virtue in this. Such bactericides as are proving their usefulness should be administered.

After-care.—These cases do best if they are not dressed too often (Macewen). It is important that the dressings be done by the surgeon himself; this is a duty that he cannot delegate to others. It is sufficient if the wound is dressed every four or five days. A built-up dressing, made by encircling the wound with rolled wool, prevents pressure on the tube. A piece of guttapercha tissue over the tube end prevents the discharge from crusting too much and occluding it (Cairns). An excellent plan is that of W. Cone, who has found that a lumbar puncture done at the time of the dressing causes the abscess cavity to open up very fully to inspection if dressed in a good light. The drainage-tube can be removed, the cavity sucked out, and the tube reinserted by the surgeon who can clearly see into the depths. At the end of three weeks, if all is going well, the stitches holding the tube may be cut. The drain will be pushed out as the cavity heals. As the wound granulates, a cerebral fungus will form; sometimes this tends to protrude and may interfere with drainage. If drainage has been good the cause of an increasing fungus is either a second abscess or encephalitis. For the latter the correct treatment is to cut down fluid intake and to perform lumbar punctures once or twice a day. The lumbar puncture needle may be left in place for two or three hours if the patient is co-operative enough. By this means a fungus can be kept in control, further aid being obtained by intravenous hypertonic solutions if need be. Lumbar puncture should not be persisted with unless it is clearly doing good, either in relieving symptoms or causing the temporary recession of the fungus. If the withdrawal of cerebrospinal fluid upsets the patient, further punctures should not be made.

Complications.—The chief causes of failure are two: (1) a misplaced tube leading to inadequate drainage: the surgeon must never be satisfied unless he has actually seen the inside of the abscess and has watched the tube enter; (2) encephalitis, which was more common after the discarded method of blind approach. If the abscess has been of fair size with a reasonably distinct wall, encephalitis of any importance is rare and, unless it reaches the ventricle, is not really dangerous. Meningitis by cortical spread is not so common as has been believed. In my view it arises by deep spread of infection around the abscess, setting up an ependymitis of the ventricle. Its probability is less the neater the approach to the abscess and the cleaner the drainage. The brain always plugs the opening in the dura and seals the superficial meningeal spaces.

EXCISION OF CHRONIC ABSCESSES

The work of Cairns in this country and Clovis Vincent in France has demonstrated the possibility of removing some abscesses *en masse* as if they were tumours, after making an osteoplastic flap. A specimen successfully removed by me from the temporal lobe is seen in Fig. 600. Such an extirpation gives an ideal result in the right case, but it cannot be done for recent abscesses. Vincent recommends turning a bone flap and palpating the abscess wall with a blunt-nosed ventricular cannula. The suitability of the abscess for enucleation can be gauged by the feel of its wall. If it is already very tough when first encountered it should not be penetrated but the dura opened and the abscess enucleated after uncapping it by removing a large piece of cortex from over it. If, on the other hand, its wall is thin, the abscess should be punctured and the pus withdrawn. Nothing more is done at that time; the bone flap is replaced, after removing its base for a decompression, and the skin sutured. As Dandy pointed out some years ago, aspiration alone may be sufficient to cure an abscess, but it cannot be relied upon to do so. If, after a temporary improvement, increasing pain and drowsiness appear again the abscess should be tapped once more. Its capsule becomes more resisting as time passes, until a point is reached when it has become safe to remove it whole in one unopened piece. Such a time may not arrive for weeks or even months, and the plan may have to be abandoned because the abscess refills so fast and so often that open drainage is clearly the only recourse.

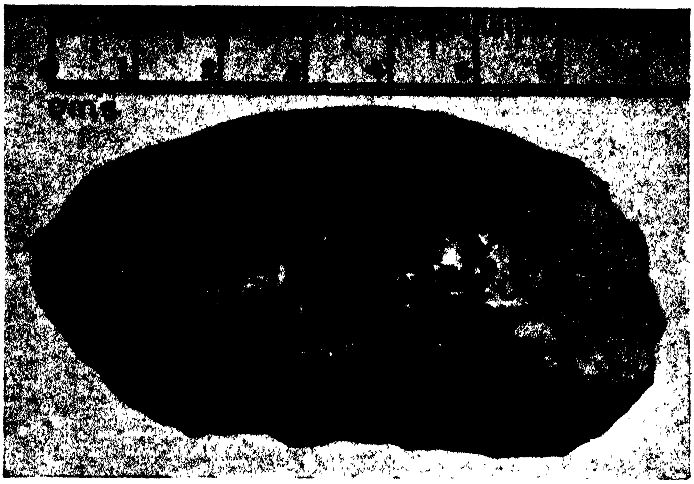


Fig. 600.—Chronic abscess of cerebrum, successfully removed intact.

The chronic abscess is a special problem of its own. Its symptomatology is that of a tumour rather than of an infective process. Commonly its contents are sterile; several recoveries are on record where the abscess has been burst whilst it was being removed, but a word of warning must be given. If the abscess wall does not separate easily from the surrounding brain, the abscess is not ready for removal in this way. Further, enucleation should never be attempted if there is a septic wound on the scalp, i.e. if there have been earlier attempts to cure it by drainage or if there are the external granulating wounds of operations on the sinusitis which is the cause of the trouble.

The ideal treatment (bone-flap enucleation) is most often applicable to chronic frontal abscesses following suppuration in the frontal or ethmoidal sinuses. Here it is not uncommon for the abscess to be already thick-walled before it is discovered. It is notorious that abscesses in this situation do badly by drainage alone.

Difficulties.—The first difficulty, especially if the abscess is frontal, will be to find it, for the surgeon may not be certain whether it is on the right or left. Ventriculography should then be done. There is no special contra-indication to this step in brain abscess ; the risk of the abscess bursting into the ventricle because of alterations in tension is small. The value of injecting a small quantity of thorotrast into the abscess, so that its site and relations can be accurately gauged, has been mentioned above.

Operations for cerebellar abscess.—Whilst acute or subacute cerebellar septic encephalitides are common, chronic cerebellar abscesses also occur and can be mistaken for cerebellar tumours. Naturally, subtentorial rapidly-expanding lesions call attention to themselves so unmistakably that long delays through ignorance or design are not often possible. None the less, encapsulation is not infrequent and the common presence of papillœdema suggests that these can often be moderately benign lesions. Surgically, in some cases the abscess can be exposed from in front of the sigmoid bend of the sinus, but not in brachycephalic skulls, for there is not enough room, however freely bone is chiselled away from the back of the petro-mastoid junction towards the internal auditory meatus. Pus may perhaps be located and the abscess collapsed by this route in any type of head, but it is usually impossible to place a tube correctly into the abscess in the modern way, and imperfect drainage accounts for the considerably higher mortality of the cerebellar abscess as compared with the temporal. The more posterior route should be adopted ; it is the method of choice though otologists are still shy of it. Given a well localized collection of pus, it should do almost as well subtentorially as elsewhere if it is properly drained.

In cerebellar abscess a horizontal incision is carried backwards for two inches from the wound of the mastoid exenteration. It should be parallel with the lateral sinus and below it. The attachments of the sterno-mastoid and nuchal muscles are dissected off the bone over as wide an area as possible. The bone behind the sigmoid bend of the lateral sinus is removed after drilling. A puncture is made in the dura a good centimetre behind the sinus (it does not matter whether this is fully uncovered or not, but its posterior edge should be clearly visible). A fine brain cannula is passed inwards and forwards, directed towards the junction of the outer and middle third of the petrous bone. At a depth of a centimetre or more the abscess should be encountered. If not, the cannula is advanced deeper. It may enter a large collection of cerebro-spinal fluid on the back of the petrous bone indicating that the case is one of "otitic meningitis" (C. P. Symonds, A. A. McConnel), and no abscess will be found. But when outspoken cerebellar signs are present an abscess, the wall of which can be recognized as a definite resistance, is always present. Its depth should be noted. After opening the dura fully, the abscess should be exposed, and drained exactly as described for a temporal abscess. except that its capsule cannot be sutured to the dura. If it is very deep it cannot be uncapped properly. The best plan then is to give up the idea of introducing a tube and to puncture the abscess and aspirate it completely, repeating the puncture every second or third day. There may well be misgivings as to the prognosis, but this procedure is better than to attempt to force a drain into a collapsed abscess; many such an attempt has ended with the tube lying outside the abscess wall. It is important to make a large opening in the abscess and to hold the tear open whilst the tube is pushed home. Difficulties in technique ought not to present insuperable obstacles to the operator who knows the ideal at which he is aiming. If no more than a puncture can be done, the injection of 2 c.c. of thorotrast is very helpful, for X-ray films may indicate a better approach or confirm the wisdom of plain puncture and aspiration as the better plan.

Difficulties.—The sufferer from an intracranial abscess occasionally stops breathing before the pressure exerted by the collection can be relieved. This danger was recognized by the early fathers of otology, was known to occur more often with cerebellar than other abscesses, and was in all likelihood contributed to by their methods of anæsthesia. An immediate puncture of the abscess will enable natural breathing to start again. The operation on the abscess must at once be proceeded with. The danger of respiratory failure means that intratracheal anæsthesia is always indicated. The difficulties of getting a satisfactory exposure of the abscess have been already mentioned. I have usually been able to excise the overlying cerebellar tissue and to insert drains under vision, but without marsupialization.

CRANIAL DEFECTS, CEREBRAL SCARS, AND EPILEPSY

The surgery of cranial defects is almost exclusively concerned with traumatic cases. Congenital malformations are rarely suitable for surgery, being so often associated with disabling mental deficiency. The indications for operation on traumatic cases are two: (*a*) epilepsy, which may be focal (Jacksonian) in type or more often generalized, and (*b*) fixed pain, especially troublesome on exertion and stooping, and worse when a considerable area of dura has been lost as well. No wound which has taken weeks to heal should be repaired until at least a year has elapsed. Pain and tenderness that the surgeon may consider to be caused by the existence of the defect may easily be due to slight infection in the bone and scar.

A deficiency in the bone is not *per se* a reason for operation. The belief that fits are produced by defects in the calvarium is almost as widespread as the idea that they commonly originate from spicules of bone pressing on the brain. The pendent notion that the fits will cease after the simple removal of the hypothetical spicule is equally common and untrue. Even a slight knowledge of the history of the surgery of traumatic epilepsy suffices to remind us that Victor Horsley always, from his first case onwards, excised the cortical scar beneath a bony depression. If, indeed, there had been no cerebral scar there would have been no fits. It can be laid down as an axiom that epilepsy can rarely be cured by an operation on the bone alone. When, for some valid reason, operation has been decided upon, the skull and dura should be repaired at the same time. Should there have been no deep injury and so small a depression that it can be removed with a trephine, the reconstitution of the skull can be effected by the substitution of a disc of the same size taken from the tibia (Fig. 601). The majority of cases requiring plastic repair have been the subject of severe local injury, with the dura torn and the brain injured to some depth. This state requires a more formidable procedure. Unquestionably the best material for the repair of the defect is bone. Many malleable metals have found their advocates, the more precious, such as gold, platinum, and silver, having the more talismanic properties. The results, however, of the simple tibial graft are the best of all, as Trotter claimed 20 years ago. Rib or costal cartilage can be used successfully ; rib is better than cartilage, but it is no more easy to handle than the tibial graft. The skull itself is a good source if the defect is no more than 5 cm. across. The operation described below is for an old open depressed fracture of the frontal bone, treated originally by débridement and bone removal ; we will imagine the patient to be subject to generalized fits.

Technique.—Since the cerebral scar must be removed, it is necessary to turn down a bone flap with the deficiency at its centre. (It would not be necessary to do this if the closure is made simply for the restoration of the normal intracranial dynamics.) The scalp and bone flaps must be reflected separately, because the attachments of the edges of the bone defect must be dissected from the skin and dura. If there has been a compound depressed fracture followed by sepsis, the cutaneous scar may be paper-thin and attached to the brain. It should be excised at a preliminary sitting, otherwise it may be so devitalised, by the raising of the skin flap, that it soon breaks down and mars the result. Such a preliminary is not necessary if there is at the site of injury only a narrow linear scar. The flap having been turned down, the deficiency in the dura occupies the centre of the field ; it is filled by a sclerotic brain scar. The dura is opened around it, leaving a narrow frill attached, and, by extending the dural incision, the cortex can be fully examined and stimulated, when necessary, with the thyrotrone to verify the position of the motor cortex. The cortical scar is then fully excised. The extirpation must not encroach on the motor area for, although a superficial excision is permissible in experienced hands, a deep removal that cuts the projection fibres would lead to a lasting paralysis. Scarring usually extends into the cerebral mass for an inch or more around the surface scar so that wide removal is called for. When there has been a penetrating wound

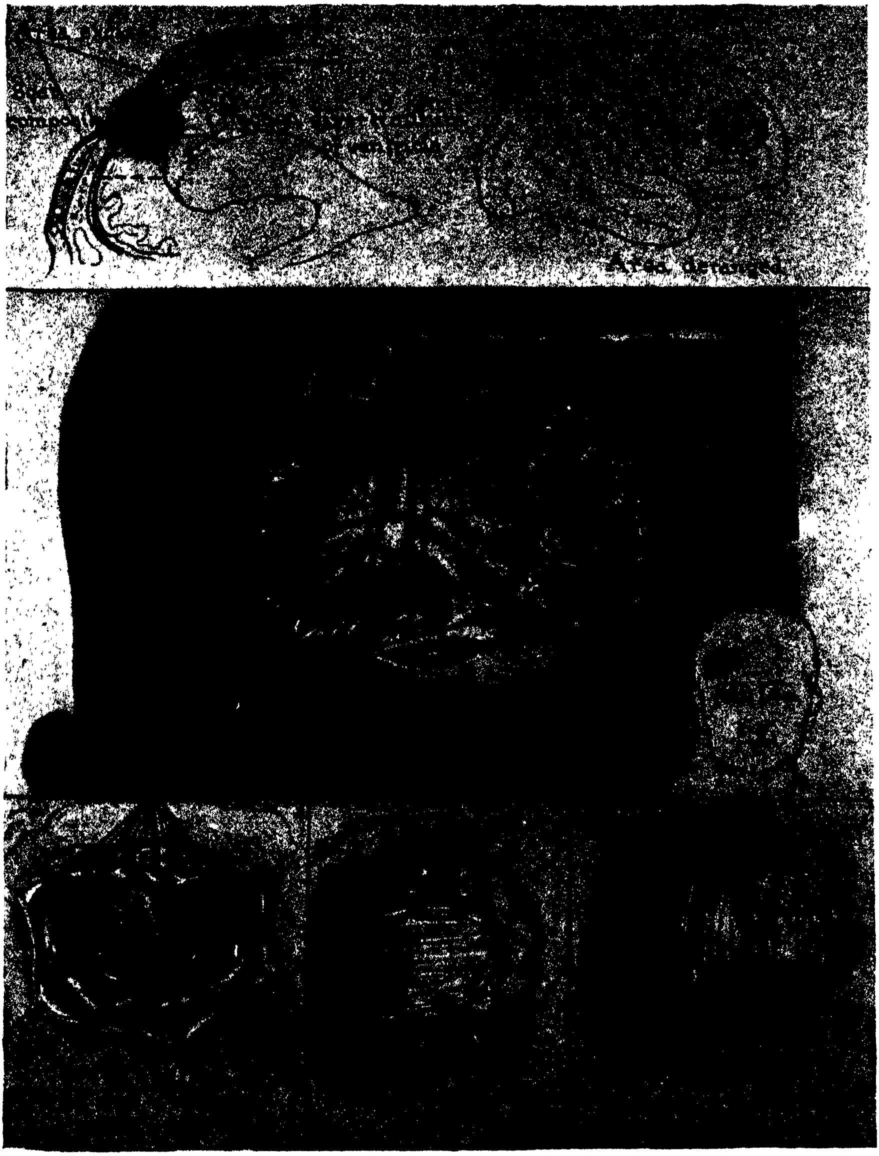


Fig. 601.—Excision of traumatic scar and repair of skull defect by bone graft from tibia.

there is a considerable admixture of fibrous tissue; after contusion the scar is less fibrotic and more glial. In these scar excisions the removal is to be carried as deep as the ventricle, for two reasons: (1) the scar often reaches almost to the ventricle and may pull out a traction diverticulum (this is well shown by pneumograms, which are useful in these cases), and (2) the filling of the gap by cerebro-spinal fluid is thought to make the re-formation of a dense scar less likely.

To complete the operation, a piece of fascia lata from the thigh is taken to close the hole in the dura left by the excision of the meningo-cerebral scar conglomerate; its careful suture in place prevents the leakage of cerebro-spinal fluid and gives the grafts something firm to rest upon. The bone flap is replaced, the edges of the original traumatic opening being freshened to accept the bone graft. This is cut with a hand-saw from the tibia; it saves time if an assistant does this whilst the cortical operation is proceeding. The graft can be cut up into lengths which, side by side, will close a considerable defect. The trabeculæ and marrow, adhering to the deep surface of the graft, are removed with nibbling forceps so that only compact bone and periosteum are left. The periosteum is useful to take stitches to hold the grafts in place (*see* Fig. 601). The edges of the graft must make good contact with the rawed edges of the defect. No drain is used, but the wound must be carefully inspected daily for effusions. The most rigid asepsis is necessary during this long operation. Smaller defects (and very large ones suggest stupidly radical bone removal at the original operation) can be closed by taking a section of outer table and diplöe, but the warmest advocate of this technique, C. C. Coleman, has recently declared against the use of calverium because follow-ups have indicated absorption. Tantalum plates and modern plastic materials, such as acrylic resin, are now in favour.

Complications.—The only important complications arise from (1) morbidity in thin scars that have not been dealt with by preliminary excision, or (2) frank sepsis because the operation has been done too soon. All epileptic patients must continue with sedative drugs for long periods after operation. In a simpler case than the foregoing it would suffice if the bone repair alone were done; but, as has been remarked, that alone is rarely necessary.

CHAPTER XXVIII

OPERATIONS ON THE EAR

By SYDNEY R. SCOTT

THE ear consists of three parts :—

(i) External : auricle and external auditory meatus.
(ii) Middle : Eustachian tube, tympanum and mastoid cell system.
(iii) Internal : labyrinth, with the auditory nerve.

THE EXTERNAL EAR

The **auricle** or pinna owes its shape to a curved, flat, ridged framework of fibro-cartilage, covered with perichondrium and skin. It is attached by a tubular prolongation of cartilage to the tympanic plate of the temporal bone. The central concavo-convex portion, known as the concha, rests closely against the external surface of the mastoid.

Displacement of the auricle is caused by inflammatory œdema of tissues between concha and mastoid, which may be due to mastoiditis or furunculosis. **Congenital defects** sometimes call for plastic operations. **Deformities** from injury are common in boxers and football players, and may also be caused by frost-bite.

The lobe of the ear is devoid of cartilage and, being easily pierced, is often used for adornment.

The external auditory meatus.—This is a curved cylindrical air-passage, circular or elliptical in section, and 1¼ inches in length, leading from the concha to the tympanic drum membrane. The walls of the outer half or two-thirds are cartilaginous and flexible ; so an observer can straighten the canal to inspect the drum membrane through a speculum. Unless the auricle be drawn upwards, backwards, and outwards, the axis of the speculum is apt to be directed to the postero-superior wall of the meatus, and the drum membrane is not clearly seen. When using the modern electric auriscope observers should make sure that they are straightening the canal, and must not introduce an unnecessarily small speculum too far and so cause pain. In the outer half of the external meatus the skin contains numerous glands which secrete cerumen or wax, variable in amount and consistency. Excess of wax and cutaneous epithelium is apt to obstruct the passage, causing deafness. It is possible that cerumen in the auditory canal is obnoxious to insects. Mothers and nurses should not try with a twisted towel to remove wax from infants' ears, which are rarely obstructed if left alone. In later life, accumulations should be removed only by a syringe or by an instrument, and the latter only in expert hands. The external auditory meatus is usually narrowest at the cartilaginous and bony junction (the isthmus). *Foreign bodies*, animate and inanimate, may be impacted here, and if forced further in towards the drum membrane are more difficult to remove. The possibility of irreparable injury to the drum membrane can be avoided only by extreme care with the aid of suitable instruments and good illumination.

The proximity of the temporo-mandibular joint and the parotid gland to the anterior meatal wall accounts for the pain and swelling in the meatus associated with some cases of *arthritis* or *parotiditis.* Compound *fractures* and displacement of the tympanic plate, with or without damage to the tympanic membrane, sometimes result from blows on the mandible, e.g. in motor collisions. A *parotid abscess* may open spontaneously through the anterior meatal wall and discharge into the meatus.

Atresia or absence of the meatus may be congenital, and is usually accompanied by abnormal development of the auricle. *Stenosis* may result from scalds or burns ; for this reason celluloid noise protectors for gunners are now forbidden. *Exostoses* and hyperostoses cause stenosis of the bony meatus.

I. FURUNCLE IN THE EXTERNAL AUDITORY MEATUS

FURUNCULOSIS of the external ear is due to infection, by the staphylococcus pyogenes aureus, of the cutaneous follicles of the outer half or cartilaginous part of the external auditory canal, with resulting inflammation which usually leads to suppuration and central sloughing, or to localized abscess-formation with surrounding cellulitis and lymphatic-gland invasion. It is important to distinguish the inflammatory conditions due to furunculosis from those due to otitis media and mastoiditis. In otitis media redness and swelling are confined to the drum membrane and deep meatus. Swelling due to mastoid periostitis is not accompanied by any swelling of the pre-auricular glands, though they are sometimes affected in tuberculosis of the temporal bone.

Some furuncles are insignificant and superficial, and no operation is required ; others are deep-seated, and the pus is slow to come to the surface. They are often multiple, or bilateral, or tend to run in sequence. The local manifestation in the external auditory meatus, or on the pinna, is frequently associated with boils elsewhere, or a stye on the eye-lid.

The surgeon should ascertain whether there is a focal source of infection, e.g. pyorrhœa alveolaris, a dental abscess, chronic tonsillitis, or rhinitis.

Indications for incision.—While some boils resolve rapidly, with or without general treatment, others are more troublesome, and call for incision to relieve tension and to drain the pus or local effusion, or remove a slough. The operation is seldom indicated before the fourth day. By this time the auricle and meatal walls may be excessively tender and painful ; the neighbouring tissues and lymphatic glands are apt to become swollen, œdematous and tender. One or more of three groups of lymphatic glands may be affected : the pre-auricular, the inframeatal, and the superficial mastoid glands.

The anæsthetic.—A general anæsthetic, e.g. nitrous-oxide gas, is necessary for all deeper-seated boils, and when tenderness is marked ; local anæsthesia, e.g. ethyl-chloride spray, suffices only for very superficial furuncles.

Local preparation.—The pinna is cleansed with ether or alcohol.

Instruments. — Short, small, sharp-pointed knife ; small curette ; probe, with wool and pure carbolic-acid or picric-acid solution ; fenestrated aural speculum (Fig. 602) ; forehead head-light. The instruments are sterilized and arranged in the usual way, and sterilized towels are placed about the patient's head and shoulder.

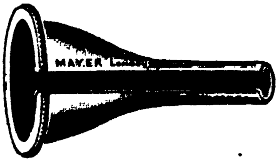


Fig. 602.—Fenestrated aural speculum.

A culture-tube should be ready for bacteriological investigation and the preparation of an autogenous vaccine if required, e.g. in case of recurrence.

For this small operation the patient may be seated in a suitable (e.g. dental) chair or recumbent in bed, if an operating-table is not available.

Incision.—As soon as the patient is anæsthetized, the speculum is inserted with the fenestrum towards the centre of the furuncle, and a free incision is made deep enough to let out pus. The curette (Fig. 603) is quickly inserted, and the slough removed. The excavation is swabbed out with carbolized wool, and the parts are cleansed. A small strip of gauze (plain or cyanide) saturated with glycerin is *loosely* introduced into the meatus, covered with a dressing and lightly bandaged.

Fig. 603.—Aural curette.

After-treatment.—The dressing is changed daily. When there is much pain or cellulitis, fomentations may be applied, but should be discontinued as soon as possible. Insufflation with boric-acid powder, or instillations of spirit drops, are in many cases preferable to warm aqueous applications.

The surgeon will find that sometimes meatal furunculosis simulates mastoiditis. He should generally have no difficulty in distinguishing these conditions, but mistakes have been made !

Results.—A succession of furuncles may prove a long and trying complaint. Attention is necessary to the general health : the diet should be generous, the surroundings hygienic, and a complete " change of air " may be necessary. It is well to try a course of autogenous vaccines; and intramuscular medication, such as collosol manganese (Crookes) 1·5 to 3 c.c., repeated three or four times at intervals of three or four days, also claims a trial. The elimination of possible focal infection in connection with infected tonsils and decayed or devitalized teeth is also important.

THE MIDDLE EAR

The middle ear comprises the tympanum, Eustachian tube, mastoid and adjacent air cells, and is developed from the first branchial cleft.

Anatomical Considerations

The normal drum membrane is a thin flexible disc which lies in an inclined plane and can be best recognized by the characteristic wheel-spoke appearance of the handle and short process of the malleus seen in the upper half of the membrane. The handle is directed downwards and backwards to the umbo or centre. At the upper anterior end of the handle the short process projects outwards like a small cone, which is more prominent when the drum membrane is "indrawn" (or really "in-pressed" by the excess of external atmospheric pressure) in obstruction of the Eustachian tube. The cone becomes ill-defined in acute otitis media when the drum membrane is inflamed, and the short process becomes unrecognizable if the membrane be infiltrated and bulging.

In front of the umbo, in the normal drum membrane, the light is reflected to the eye from a triangular area often erroneously described as "the cone of light." (The true cone is the short process.) This misnamed "cone of light" is inconstant, for it may be replaced either by a small circular or by a crescentric lustrous area, according to different degrees of inclination of the drum membrane in relation to the axis of the meatal canal.

The extreme upper section of the drum membrane is sometimes lax and translucent—"pars. flaccida" or Shrapnell's membrane. Sometimes white circular opaque plaques are seen in the membrane either in front of or behind the malleus. These opacities may be due to past inflammation, but also occur without known cause.

The appearance of diseased or injured drum membranes is extremely variable; there may be perforations, granulations, or scar tissue. Discharge, epithelial débris, and wax must be removed before attempting to interpret the otoscopic appearances.

The Eustachian tube leads through the lateral wall of the naso-pharynx, close behind the posterior nares, upwards, outwards, and backwards into the tympanum. The pharyngeal part of the tube is 2–2½ cm. long, and is smooth and flexible, having a fold of cartilage forming its roof and inner wall. The tympanic portion of the Eustachian tube is a bony canal 1–2 cm. long. The osseous part of the tube develops from the cleft between three parts of the temporal bone which are un-united at birth: the anterior crus of the tympanic ring and the posterior margin of the glenoid fossa of the squamous part of the temporal bone externally, and the lateral wall of the carotid canal in the petrous bone mesially. In early infancy the tympanic ring broadens laterally into a trough. Its anterior wall expands, becoming the vaginal plate to complete the glenoid fossa. The three bones eventually fuse to form the osseous Eustachian canal. The walls of the pharyngeal portion are in contact with each other except when separated by action of the palato-pharyngeal muscles during deglutition when the tube is opened momentarily. Through the efficient mechanism of the tube the air pressure is maintained level within the tympanum, despite changes of atmospheric pressure outside. Motoring in mountainous districts, ski-ing and flying make great demands on the regulative mechanism of the. Eustachian tube owing to the rapid changes of altitude and of barometric pressure. Caisson workers and miners are, for similar reasons, especially liable to painful and disagreeable symptoms, the Eustachian tubes failing to function normally during exposure to rapid changes of air pressure. Such symptoms include pain in the ear, headaches, deafness and, especially when the disability is unilateral, staggering, vertigo and vomiting. These disturbances arise quite apart from oxygen-want or increased blood-oxygen.

The mucosa lining the Eustachian tube is columnar ciliated. The cilia " thrash " towards the pharyngeal end. Obstruction in the Eustachian tube is commonly associated with " colds in the head," adenoids and pharyngitis, and is due to the hyperæmia or œdema of the mucous membrane.

When swallowing fails to regulate the air-pressure through the Eustachian tube, one of three other methods may be adopted: (1) The mouth and nostrils are kept closed while the patient forces the air from the lungs into the bulging cheeks and into the tympanum (Valsalva's and Eustachius's method). (2) The patient fills his cheeks with air, and keeps the lips tightly closed as he occludes one nostril with the finger, while the nozzle of a Politzer's bag is inserted into the other nostril. The bag is suddenly compressed to drive more air into the nose and pharynx, and force open the Eustachian tube (Politzer's method). Alternatively the patient may swallow a mouthful of water instead of bulging the cheeks, the Politzer bag being compressed as the pharyngeal muscles contract. Methods 1 and 2 are especially useful in children, and much of Politzer's early renown was attained through the remarkable success of method 2.

(3) The modern method is by catheterization, which in pre-Listerian days was undoubtedly dangerous, and is usually unacceptable without local anæsthesia. Catheterization is preferable for diagnostic as well as for therapeutic purposes. An auscultatory rubber tube with ear-pieces enables the observer to detect when air enters the patient's tympanum through the Eustachian tube. The catheter should be passed along the floor of the nose as far as the entrance to the Eustachian tube, preferably after the preliminary application of a

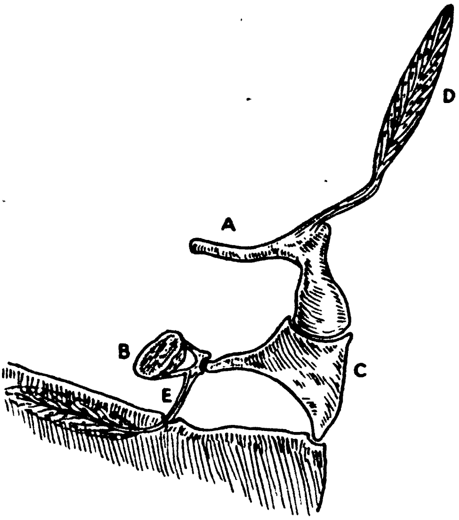
local anæsthetic to prevent palatal muscle spasm, which often defeats the attempt. The correct interpretation of different sounds produced by inflation can be made only after trial and experience. Sometimes the sounds resembles those of the mucous râles heard in the respiratory passages. Other sounds are of air moving the tympanic membrane and escaping through a perforation, which must be distinguished from the feeble sounds of air forced against the pharyngeal wall. Care must be taken not to make a false passage with a catheter and cause surgical emphysema of the pharynx, soft palate or neck.

The **tympanum** is the air chamber in the middle-ear cleft between the tympanic membrane and the internal ear. It is a narrow irregular cuboidal space with six walls. Anteriorly it opens forwards and downwards into the Eustachian tube, and postero-superiorly leads upwards and backwards to the mastoid antrum. Inflammatory processes in the tympanum due to infection *via* the Eustachian tube are common causes of deafness and discharging ears. The lateral wall of the tympanum is formed chiefly by the tympanic membrane but partly by the bone adjacent to the tympanic ring. Timely incision of the membrane is necessary to drain inflammatory exudation from the tympanum, e.g. in cases of otitis media, and diminishes the liability to chronic disease and permanent deafness. The roof of the tympanum, or tegmen, is a thin plate of bone which forms a small part of the floor of the middle cranial cavity. Through this plate infection in the tympanum is able to penetrate the cranial cavity, leading to meningitis or to abscess in the adjacent temporo-sphenoidal lobe. The floor of the tympanum covers the jugular bulb, and through this floor infection sometimes extends directly into the jugular vein, causing septicæmia.

The inner or mesial wall of the tympanum is formed by the parts of the cochlea and vestibule of the labyrinth. An elevation, or promontory, faces the drum membrane and is formed by the first whorl of the cochlea. On the mesial wall behind the promontory is a depression bisected by a ridge ; of the two small fossæ thus formed, the upper, called the pelvis ovalis, lodges the stapes, the foot-plate of which fits the oval window of the vestibule of the labyrinth and is maintained in position by means of an annular ligament which normally permits slight mobility. The lower fossa, or fossula rotunda, lies opposite the lower or postero-inferior part of the drum membrane, and is important because its anterior wall is formed by the membrana rotunda, which separates the fluid of the cochlea from the air of the tympanum. The function of hearing is affected by the condition of the membrane of the round window, as well as by the mobility or fixation of the stapes; fixation may result from disease, e.g. otosclerosis. Knowledge of the position and relation of the stapes is necessary to avoid its accidental displacement, particularly during operations on the middle ear. Dislocation of the stapes is a cause of post-operative labyrinthitis.

Lying in the inner wall of the tympanum is the bony canal of Fallopius, through which runs the facial nerve. The canal curves from above the stapes downwards, entering the posterior tympanic wall and ending lower down at the stylo-mastoid foramen. Fracture of the temporal bone and inflammation of the middle ear are common causes of facial paralysis. There is also danger of injury to the nerve during operations on the ear.

The three **auditory ossicles**—malleus, incus and stapes—form a jointed flexible arch connecting the tympanic membrane with the labyrinth. The incus (Fig., 604 C) supplies the middle of the arch, forming ball-and-socket joints with the malleus (*A*) and with the stapes (*B*). It pivots on the end of a short arm which rests on the floor of the aditus (*C*), i.e. the canal which leads from the tympanum to the antrum. The ossicular chain is like a lever of the first order with a median fulcrum. There are two intrinsic muscles acting in opposition, the tensor tympani attached to the malleus (*D*) and the stapedius to the stapes (*E*). Acting together they control the rigidity of the ossicular chain, the tension of the tympanic membrane and also the footplate of the stapes, and thus vary the tension of the membrana rotunda through the perilymph of vestibule and cochlea. Chronic suppuration in the middle ear sooner or later leads to destruction of the ossicles. The incudo-stapedial joint and the incus are generally the first to be destroyed.



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Otitis Media

Acute otitis media is an infection of the mucosa lining the middle ear by organisms (pneumococci, streptococci, or staphylococci) which invade the cavity from the naso-pharynx. An inflammatory process is initiated, resulting in exudation of the products of suppuration into the normal air-spaces of the tympanum. (Fig. 605.) The infection may be localized, or may be diffused throughout the mastoid antrum and accessory cells in the petrous bone.

The surgical principles for dealing with infective material should be applied in all cases of otitis media without delay. A free incision is made into the tympanic cavity, dividing the bulging membrane from edge to edge. It is quite contrary to the elementary principles of treatment to wait for the ear to discharge spontaneously. If possible, the incision should be made in less than twenty-four hours from the onset. Delay in providing early and free drainage for infective inflammation in the middle ear is responsible for many of the cases of permanent deafness resulting from scarlet fever, measles and influenza.

Children often fail to draw special attention to the ears, though one or both may be acutely infected and may be the actual cause of grave general symptoms. The sudden appearance of otorrhœa, or the discovery of a superficial mastoid abscess, may be the first sign of otitis media. This serious condition can be overlooked unless a daily inspection of the drum membranes be made in all patients, especially children, with infections of the upper air-passages associated with an exanthematous fever (including typhoid), or with pneumonia, though there may be nothing to direct special attention to the ear. The greater the resistance to examination, the more important it is to inspect the drum, and to be prepared to perform myringotomy.

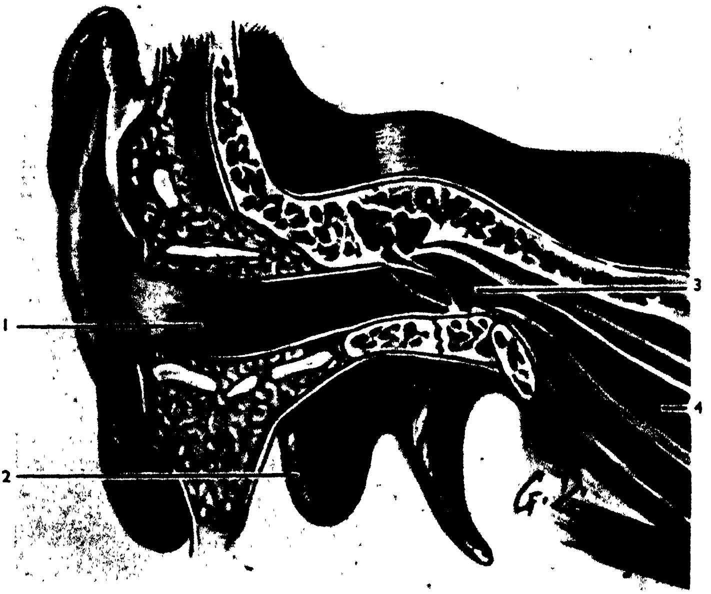

Fig. 605.—Oblique vertical section of external and middle ear.
1, External auditory meatus ; 2, mastoid process ; 3, tympanic cavity ; 4, Eustachian tube.

The notion prevalent, not only with the laity, that incision of the tympanic membrane causes permanent deafness is erroneous. On the contrary, this procedure will more often prevent deafness after otitis media, and hastens recovery.

Indications for myringotomy.—There is generally more or less pain or discomfort, with some deafness in the affected ear, though sometimes the pain lasts only a few hours and is followed by a sensation of numbness in the region of the ear. The tympanic membrane is bulging, rarely flat; it is red, or blue or white. With the head inclined forwards or backwards the fluid in the tympanum is rarely seen. A bulla containing dark fluid sometimes obscures the landmarks. A bulging drum may have a curious speckled-white appearance, due to the stretching apart of the mosaic-like areas of epithelial scales.

When watery, blood-stained serous fluid spontaneously discharges from a bulla on the tympanic membrane, incision into the tympanum will still be necessary.

Anæsthetic.—A general anæsthetic should be given: nitrous-oxide or evipan is best for adults and children, while ethyl chloride is especially suitable for infants.

Instruments.—Only three are essential: a myringotome (Fig. 606, B)—straight, bayonet-shaped, or angular, according to choice (a fine sharp tenotome can be used in emergencies); an aural speculum—the largest the meatus comfortably admits; a frontal mirror or head-lamp.

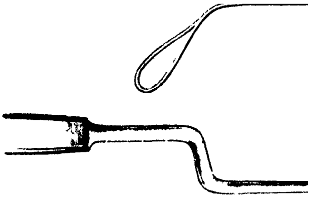

Fig. 606, A.—Small aural probe (Hunter Tod's pattern).
Fig. 606, B.—Myringotome.

Preparation.—The instruments should be sterilized by boiling. The operation can be done without moving the patient out of bed, but an operating-table, if close at hand, may be more convenient. The patient may be seated in a chair if the general condition permits. The skin of the ear is cleansed with ether or alcohol, but it is undesirable, and quite unnecessary, to syringe the meatus with antiseptics, or to apply iodine to the drum.

The incision.—The surgeon should introduce the speculum, adjust the patient's head and the light, and, having removed any wax or epithelial débris, should decide on the precise line of incision and make a clean cut across that part of the drum membrane which bulges. If the landmarks are definable the incision should be behind the handle of the malleus. The surgeon must take care not to thrust the point of the knife against the incus or stapes, or to penetrate so deeply that he might puncture a high, thin-walled jugular bulb which is rarely associated with bony dehiscence of the tympanic floor.

One incision should suffice. Multiple incisions imperil the hearing. If, later, the question of a second incision is raised, it will only be because pain or pyrexia persists, and in that case there will probably be additional reasons for opening the mastoid rather than lacerating the drum membrane.

Dangers.—In practice the dangers are negligible, though dislocation of the stapes, also hæmorrhage from a high, thin-walled jugular bulb, have occurred.

After-treatment.—Immediately after the incision an aseptic dressing (no meatal plugging) is laid on and, when consciousness returns, a hot fomentation is applied. The patient may assume any desired position except the dorsal decubitus ; change of posture tends to aid drainage. Lying on either side, with the face turned half-down, is advocated on hypothetical grounds. For insomnia, a sedative such as aspirin or morphia, should be given.

Attention must be paid to the general health, and to the infection of the upper air-passages which preceded the otitis media. The surgeon should always bear in mind the possibility of latent pneumonia, the early recognition of which may be difficult.

The local after-treatment consists mainly in re-applying hot fomentations. After a day or two, an antiseptic non-irritant lotion at the patient's temperature, or (say) 101° F., is used to syringe the ear, as discharge becomes less blood-stained and more muco-purulent.

In from one to two weeks the discharge and pain should have quite, or almost, ceased. Finely pulverized, dry boric-acid powder may then be insufflated. Continuance of discharge in and after the third week should be a cause of some apprehension, and vigilance.

Inflation of the ear may be commenced when the pain has subsided, and should be repeated from time to time, as long as discharge is present and until air re-enters the tympanic cavity during deglutition. If otorrhœa persists, it may be accounted for by the condition of the nose and naso-pharynx.

MASTOID OPERATIONS

Surgical anatomy.—The mastoid process is barely distinguishable at birth but develops rapidly during the first year. Contrary to the statement* that cells do not develop before puberty, fuller experience shows that they may be present even before the end of the first year. On the other hand, they may never develop, even at puberty. In 30 per cent. of normal adult temporal bones there are no cells in the mastoid process beyond the antrum ; and in 30 per cent. the mastoid process from base to apex consists of nothing but large thin-walled cells. In some cases the cells extend beyond the limits of the mastoid process, invading the root of the zygoma, or the adjacent occipital and parietal bones, even to the apex of the petrous bone. This variable pneumatization accounts for the occasional infection in the apex of the petrous bone around the carotid canal beneath the semilunar ganglion. Sometimes cells envelop the bony labyrinth. (Figs. 607, 608.)

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* "Pyogenic Diseases of the Brain and Spinal Cord" (W. Macewen).

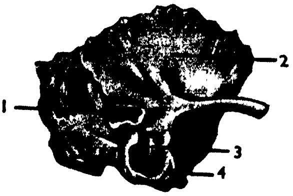

Fig. 607.—Right temporal bone in early infancy, showing tympanic ring. Outer wall of antrum has been removed.

1, Antrum ; 2, squamous portion ; 3, malleus ; 4, tympanic ring.

This chapter is concerned with the orthodox mastoid operations, but it is well to bear in mind that modifications are sometimes necessary to gain access to cells more remotely placed. Such a modification is Ramadier's operation through the carotid canal. Severe otitis media involving the extensively pneumatized temporal bone presents features which differ from those due to otitis media in acellular mastoids. In the former case abundant otorrhœa and tenderness over the whole of the mastoid and particularly near the apex, are frequent, while the patient with a non-cellular mastoid is less likely to have profuse discharge or apical tenderness. Operations on the mastoid performed for mastoiditis in the acute stages nearly always reveal very cellular mastoids, while in those operations necessary in chronic otitis media, the absence of a cellular system in the mastoid process is notable. Two explanations have to be considered. Does the absence of cells imply that the chronic disease has led to new bone formation, which has displaced the cells believed to be previously present ? Or is it not more probable that the non-cellular mastoid in chronic otitis media has always been non-cellular ? The disease may have become chronic because there was no urgent indication for drainage in its early stages.

Relations of the mastoid antrum and cells.—The antrum and cells are behind the tympanun and external auditory meatus. A depression on the outer surface of the bone of the mastoid immediately above and behind the meatus (that is, the area of the suprameatal triangle of Macewen) is a safe surface guide to the antrum. The distance from the

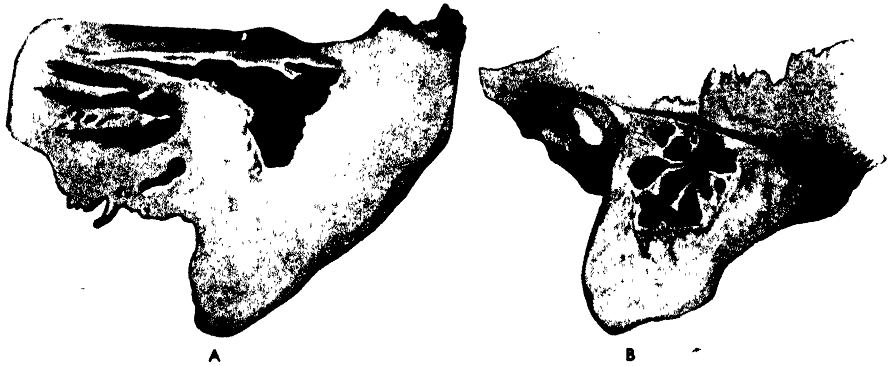

Fig. 608.—Vertical sections of mastoid process to show (A) acellular and (B) partially cellular varieties.

A is in oblique vertical plane, B in antero-posterior plane.

surface to the antrum varies considerably ; the inner wall may be 3 cm. from the outer surface, but is sometimes only half that distance, When the mastoid process is cellular, it is safer to follow the chain of cells from the apex upwards and inwards, until the antrum is reached.

Indications for opening the mastoid.—It may be taken as an accepted fact that the dangers of intracranial complications, and the risks of protracted suppuration and permanent defect in hearing, are evils which can be minimized by drainage of the middle-ear cavities through the mastoid region, in those cases in which incision of the drum membrane only does not result in speedy recovery. There is a group of cases of acute otitis media in which the mastoid cells appear to be affected almost from the onset of symptoms, although the mastoid region is not necessarily tender to digital pressure. Many examples of fulminating meningitis, due to mastoiditis of a few hours' duration, could be cited. Let it suffice to quote one.

A medical student, previously well, awoke with earache after a visit to swimming-baths. Spontaneous discharge next day gave relief, but in less than 36 hours the temperature rose to 102°, and next morning was 104°. Pulse 84. Semi-comatose at 9 a.m. He died at noon, eighty hours after the onset. The autopsy proved that streptococci were spread throughout the meninges of both brain and spinal cord. Histological sections of the opposite frontal lobe, cerebellar cortex and cauda equina showed the presence of long-chained streptococci in the pia-arachnoid in every section. The mastoid cells were full of pus. There was no excess of cerebro-spinal fluid, and no anæsthetic had been administered.

When one clean incision of the drum fails to relieve pain, or pyrexia or mastoid tenderness, or headache, repeated laceration of the membrane proves equally ineffectual.

Tenderness is not necessarily an indication for immediate operation, especially tenderness of the apex of the mastoid in the earliest stages of otitis media, as it often disappears within 24 hours if the tympanic membrane has been incised.

Whenever **mastoid tenderness** develops for the first time or persists or increases *after* the drum membrane has perforated, or has been incised, the necessity for opening the mastoid becomes clear. Tenderness to quite gentle pressure with swelling or œdema may indicate mastoid periostitis. The common seat of initial tenderness to *steady* pressure is on the apex of the mastoid, but sometimes tenderness is confined to the base, and often to one or more definite areas, above or below the course of the lateral sinus.

How, in the absence of mastoid tenderness or swelling, can the surgeon judge whether the drainage through the opening in the drum is insufficient and that the mastoid should be opened ?

(1) The onset of **headache and drowsiness** indicate that there is no time for delay.

(2) **Profuse discharge with pyrexia.**—The amount of discharge is

proportionate to the discharging area ; if its origin is in the tympanum alone, discharge is never profuse. Pyrexia shows that, however free the discharge may be, it is not free enough. If pyrexia increases in spite of discharge, or even if it diminishes but continues after, say, the fifth day, the mastoid should be opened without hesitation.

While a certain degree of pyrexia is the rule (101°–102° F.), this may be quite slight (99°–100° F.), and it is not uncommon to find the mastoid cells full of pus with normal or even subnormal temperature (97°–98·4° F.). Exceptionally, the temperature is 104° or 105° with no evidence of infection beyond the tympanum.

(3) **Pain.**—When the discharge from the opening in the drum is not profuse, but there is continuous pain, deep-seated, throbbing, and pulse-like, the necessary steps to open the mastoid should be taken within twenty-four hours.

(4) **A furred tongue** is a useful general guide to infective absorption. On the other hand, the surgeon should not be deterred from operating because the patient has a clean tongue, when pain or pyrexia accompanies the otitis media.

(5) **Latent mastoiditis, extradural abscess** (Fig. 609).—For some weeks after the inflammation of the drum has resolved and the hearing possibly returned to normal, there may be latent suppuration in the mastoid cells, or between bone and dura, sigmoid-sinus thrombosis, or brain abscess, or localized meningitis.

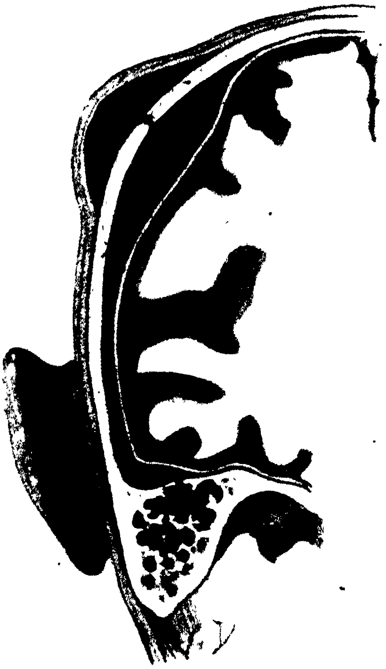

Fig. 609.– Extradural abscess : coronal section of head to show abscess originating in mastoid disease and pointing in parietal region, causing subpericranial abscess.

Schematic, to illustrate condition in a patient who recovered.

(6) **Swelling due to mastoid periostitis.**—An early sign of periostitis is the swelling sometimes seen in the roof and posterior wall of the *bony* meatus. " This so-called sinking-in of the posterior upper wall of the meatus, the result of periostitis in this region . . . is an imperative command to open this [the antral] cavity " (Heine, quoted by Ballance). The surgeon must discriminate between swellings in the osseous and cartilaginous parts of the external auditory canal, the former being associated with otitis media, the latter with furuncles and otitis externa.

It should be remembered that swelling and tenderness over the mastoid do not necessarily imply periostitis beneath. The application of a blister, or leeches, causes superficial swelling and tenderness, and these measures, however beneficial they may have been considered in the past, confuse the issue, and are therefore not now recommended. On the other hand, the lymphatic glands superficial to the mastoid may be infected from mastoiditis or from a furuncle, or from an eruption in the scalp, either of which may co-exist with otitis media.

(7) **Macewen's type of mastoiditis.**—The post-auricular groove, when compared with that of the opposite ear, often shows early evidence of swelling. The auricle may be displaced forwards and downwards owing to the conchal cartilage becoming separated from the os planum of the mastoid by the inflammatory effusion both in mastoiditis and in furunculosis. It is not necessary, in cases of mastoiditis, to wait until superficial fluctuation is elicited.

(8) **Zygomatic type of mastoiditis.**—The periosteal effusion may take an upward course, leading to a swelling beneath the scalp immediately above the ear and spreading along the zygoma. When this condition is encountered for the first time, the surgeon may fail to realize it as a complication of otitis media. Recent literature contains numerous examples of this indication of mastoiditis.

(9) **Bezold's type of mastoiditis.**—Pus may find its way spontaneously from apical mastoid cells into the digastric groove and so into the connective tissue of the neck beneath the sterno-mastoid muscle ; it may travel downward, penetrating the upper cervical region, causing rigidity of the sterno-mastoid with swelling and tenderness beneath this muscle, about the level of the transverse process of the atlas vertebra. The abscess may very rarely open into the sheath of the sterno-mastoid and may point above the clavicle. Or it may burrow forwards as a retro-pharyngeal abscess.

(10) **Severe giddiness with acute otitis media, or the onset of facial paralysis,** is generally an indication that the surgeon should prepare to open the mastoid.

(11) **Persistent otorrhœa,** with the patient well and attending to his affairs. In this group the surgeon may have to consider whether the mastoid operation is essential or not. The otitis media may have been recognized early and treated by incision within a few days, or the patient may not have been seen until the ear had begun to discharge spontaneously. The discharge seems to be quite free ; there is no pain or discomfort ; no pyrexia ; only a certain degree of deafness, little or no tinnitus, but the discharge does not stop. All active rhinitis has ceased ; there are no adenoids or infected tonsils, and the possibility of maxillary or sphenoidal-sinus suppuration can be outruled.* Still the otorrhœa continues, though the patient feels well. It may go on for three, four, six weeks, six months, nine months, or even two years or longer, without any serious disturbance of health or comfort. How

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* Cases of acute otitis media are not uncommonly associated with nasal-sinus infection ; the latter may be overlooked unless sought as a routine.

long ought the surgeon to wait ? What should he do ? There is no polypus, only a small perforation which oozes steadily and persistently. The application of suction (Siegle's speculum) may draw out a bead of pus ; the discharge, at first a little less, re-appears, but does not cease.

It should be borne in mind that persistent painless otorrhœa originating in adults, especially when approaching or beyond middle age, is rarely accompanied by those *external* signs of mastoid disease with which we are familiar in children and young people. The danger of alarmingly rapid onset of labyrinth infection, often quickly followed by meningitis, is too familiar to those who have much experience of this disease.

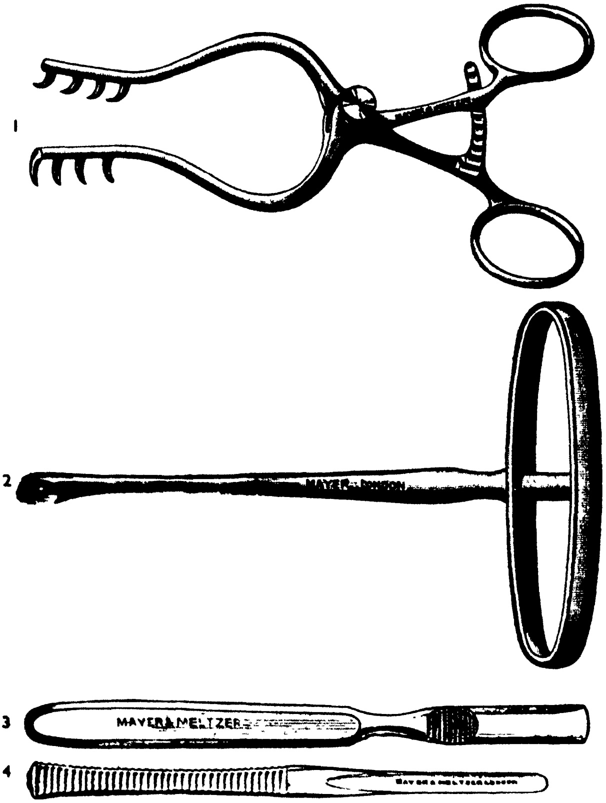

Fig. 610.—1, Mastoid wound-retractor ; 2, cross-handled curette ; 3, periosteal elevator ; 4, gouge.

There is no definite time limit by which to judge how long painless suppurative otitis media may continue, but if, *while under treatment*, there is no further sign of the discharge diminishing, the time for operation has arrived.

Attempts to avoid the mastoid operation, by total excision of the tympanic membrane and extraction of the ossicles, are strongly disapproved, in acute otitis media, because hearing is irrevocably and unnecessarily destroyed; the dangers of labyrinthitis and fatal meningitis are greater than in the simple mastoid operation; and the ossiculectomy may prove futile, either not curing the discharge, or only curing it at the price of lost hearing.

Preparation.—The patient is prepared as for any other major operation. The hair is shaved from the region to be dealt with and the skin cleansed with ether and alcohol. When tenderness is marked and the patient timid, or the general condition grave, the surgical toilet of the head can be deferred until anæsthesia has been induced.

The anæsthetic.—The choice may be left with the anæsthetist, who will judge by age, the state of the bronchi and lungs, and the general condition. He should allow at least half to three-quarters of an hour for the operation on one ear. A preliminary injection of atropine is advisable.

Instruments.—The special instruments required are: a periosteal elevator, a wound-retractor, gouges (various), a hammer, curettes, bone-forceps, a head-light, and a myringotomy set. (Figs. 610-612).

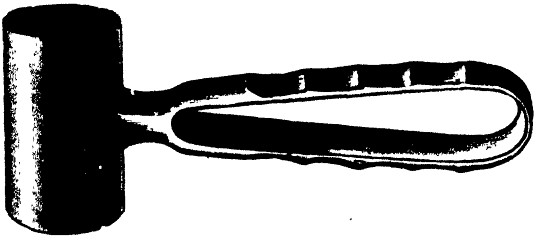

Fig. 611.—Heath's Hammer.

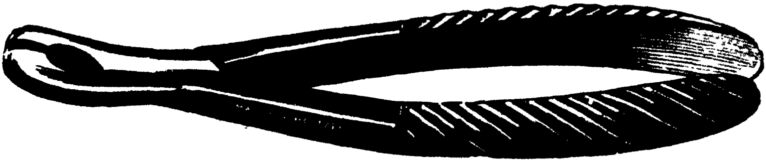

Fig. 612.—Bone-nibbling forceps.

Position.—A convenient position is for the patient to be on the back, with the face turned away from the side to be operated upon. The surgeon stands by the patient's shoulder on the side to be operated upon. The anæsthetist is at the opposite side of the table to the surgeon. The chief assistant stands at the head of the table.

Technique of Schwartze's operation.—A curved incision is made through the skin behind the pinna, beginning at its upper attachment to the scalp. (Fig. 613.). One which curves back semicircularly, nearly as far as the hairy margin, and terminates just behind the apex of the mastoid will prove more generally useful than one limited to the postauricular groove. The surgeon then detaches and reflects the

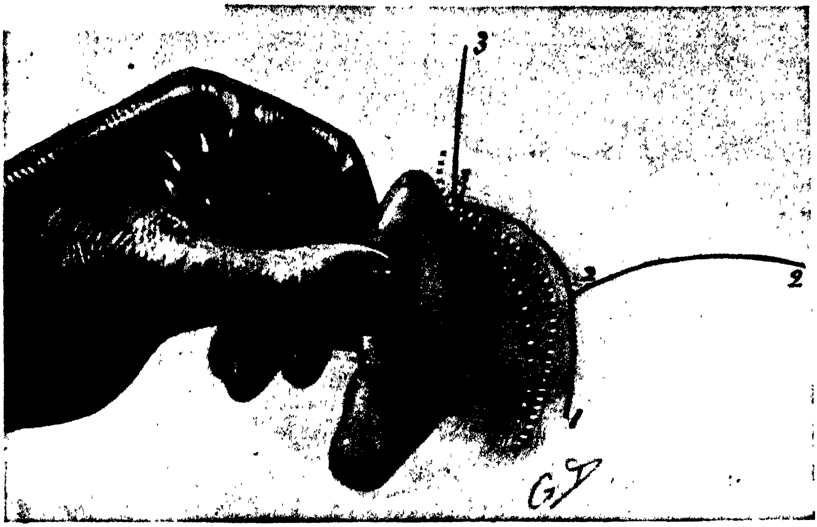

Fig. 613.—Incisions for mastoid operations, etc.

1, 1, For Schwartze and radical mastoid operations; 2, 2, extension for lateral-sinus thrombosis and cerebellar abscess; 3, 3, extension for temporo-sphenoidal abscess. An incision following one of the dotted lines does not give such a free exposure.

integuments forwards to expose freely the whole mastoid area. Three or four vessels may need the application of artery forceps.

In the upper part the aponeurosis of the temporal muscle is exposed (Fig. 614), but should not be opened unless involved in suppuration. The periosteum of the os planum of the mastoid must be divided with

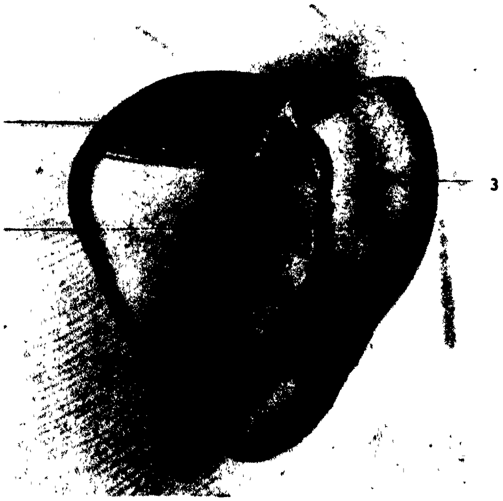

Fig. 614.—Schwartze's operation, first and second stages incision and reflection of integuments.

1, Temporal muscle · 2, suprameatal fossa 3, posterior surface of pinna.

the knife and detached forwards and upwards with the raspatory. In the lower part the attachment of the tendinous fibres of the sterno-mastoid to the periosteum of the mastoid should be severed with the scalpel. This latter procedure should be carefully and thoroughly accomplished to prevent fragments and chips of bone adhering to the sterno-mastoid, as they are apt to necrose and interfere with subsequent healing.

The fibro-cartilaginous meatus is not detached from the bony meatus, unless the posterior wall of the osseous meatus is to be removed.

The self-retaining retractor is now inserted (Fig. 610).

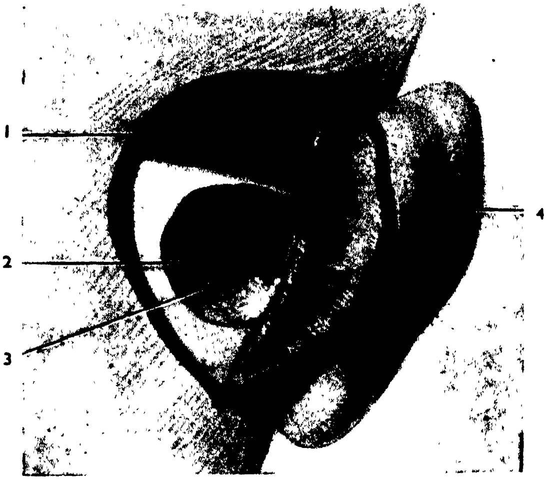

Fig. 615.—Schwartze's operation, third stage : removing the cortex.
1, Temporal muscle ; 2, operation cavity ; 3, antrum ; 4, pinna.

Having thus displayed the whole outer surface of the mastoid with the suprameatal spine and fossa, the operator looks out for any superficial granulations, or pus, or sinus in the bony cortex. Thin layers of bone are chipped away with gouge and hammer, beginning, say, halfway between apex and base, working radially upwards and forwards, towards the suprameatal fossa (Macewen's triangle). (Fig. 615.) As the cavity deepens, the chips are taken successively from the outer and lower edge of the cut bone ; the whole cortex from the tip of the mastoid and behind it is removed upwards, forwards, and inwards towards the antrum as the chief objective. Whether containing free pus or only swollen mucosa, each cell must be ablated and its walls levelled down. Having dealt with the apical cells, the operator may discover a chain of cells extending downwards from the antrum, or backwards below the level of the sigmoid sinus, or another chain more directly backwards, above the level of the sigmoid sinus towards the petro-squamo-parietal sutures. Again, he may find other cells leading forwards in the roof of the osseous meatus, and even into the root of the zygoma ; all must be opened up and obliterated. (Fig. 616.) Opening the vertical chain of cells from the antrum may in some cases lead the surgeon to expose the facial nerve.

The dura mater or the sigmoid sinus is likely to be exposed. No harm will be done if care is taken to avoid even superficial abrasions of the dura. It is often well to expose the dura deliberately, for thus an unsuspected extradural abscess is sometimes discovered. In this event the surrounding bone is cut away more freely, until the limits of the abscess and a ring of healthy dura are laid bare. To do this, special narrow bone-forceps may be useful. (Fig. 617.) If the wall of the sigmoid sinus appears to be thickened or discoloured, it must be scrutinized with care, for there is always the possibility of sinus infection, even without the classical symptoms. Apart from the external appearance, the surgeon will consider the general condition of the patient regarding pyrexia, as well as the duration of the disease, before he decides whether to explore the interior of the sinus at once, or to await further clinical developments.

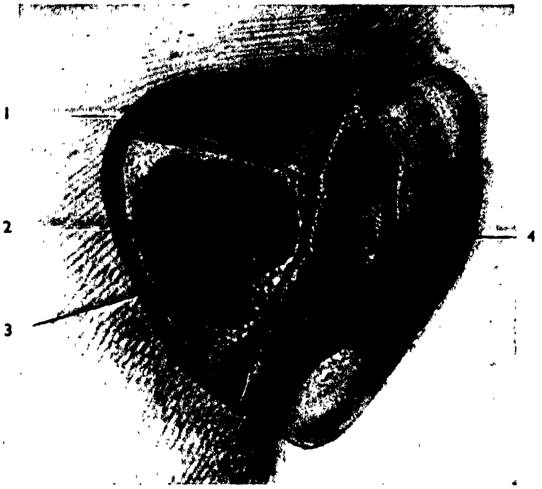

Fig. 616.—Schwartze's operation, fourth stage : opening the mastoid cells.
(For references *see* Fig. 615.)

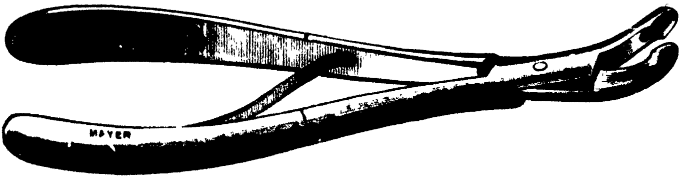

Fig. 617.—Narrow bone-nibbling forceps.

Effectual drainage of the antrum and tympanum has now been provided, and it is unnecessary to sever the tympanic ring, unless the simple operation is deliberately to be converted into the radical.

In removing the outer antral wall, special care may be necessary not to disturb the poise of the incus. It is unwise to introduce a seeker into the aditus, or even forcibly to syringe into the antrum, for it is easy thus to dislocate the incus, and should it be dislodged the hearing is permanently affected.

When an electro-motor suction apparatus is employed to facilitate removal of blood during the operation, the incus and even the malleus may be removed by suction if the suction tube is unintentionally inserted into the aditus!

The retractor is now removed, and the small vessels are ligatured.

To close the wound completely is a method advocated by few surgeons* and not recommended here, although some cases have been satisfactorily treated in this manner. It is better to suture the upper part and insert drainage-tubes at the lower end. Two or three small tubes, lying parallel, are more comfortable than one large tube, and appear to be equally efficient. Only when a peri-sinus abscess has been discovered should the wound be left more widely open ; the opposing surfaces can then be kept apart by introducing rubber strips. This is much more efficient and comfortable than gauze plugging.

The skin in the area operated upon and the hair at the back of the head are freed from any adherent bloodclot, and dry dressings, wool, and bandage are applied. If the first dressing be besmeared with sterilized vaseline, or saturated with glycerin, its removal next day is greatly facilitated. The patient is then returned to bed.

After-treatment.—The patient should lie on the healthy side, and a nurse should remain by him in case of vomiting. Pain occurs if the head is so placed that the sterno-mastoid on the side operated upon is extended. To relax the muscle, the face is turned to the opposite shoulder and the head raised on a pillow to incline the operated region towards the sterno-clavicular joint of its own side. When the operation has been performed on both sides, the patient lies on one side until consciousness returns. He then is normally most comfortable on his back with a pillow to flex the neck and so relax both sterno-mastoid muscles.

An early purgative, a diet suitable to the appetite, cleanliness of the mouth, a four-hourly watch on the temperature and pulse, possibly an initial sedative—such is the routine in every case. The surgeon must keep a continuous lookout for all signs suggestive of systemic or local intracranial infection, the possibility of which should never be absolutely dismissed. He must also expect to meet certain cases which develop acute cellulitis of the wound area after the infected mastoid cells have been evacuated, and, occasionally, erysipelas.

Local treatment.—For a few days severe pain may be caused by movements of the head, but such pain can be prevented by avoiding active contraction or passive stretching of the sterno-mastoid muscle on the affected side. The patient should not raise the head unaided.

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* e.g. The late Clarence Blake, based on the late Prof. Halsted's observations.

Nurses who move the patient should support the head and shoulders together, keeping the head and neck flexed forwards with the chin inclined towards the shoulder of the unaffected side. As a rule, the dressings need not be removed for several days. Nevertheless, to change the first dressing in 24 or 36 hours makes the patient more comfortable. When both mastoids have been operated upon, it is easier to carry out dressings painlessly, with the patient sitting up and facing downwards, to relax *both* sterno-mastoid muscles. The second dressing can often be left on for two or three days. When there is no cellulitis the sutures are left for five or six days. Probably no more pus will be seen in the meatus, only a little dry blood. This can be left for a time ; the meatus need not be syringed unless pus is present.

The tubes may be loosened about the fourth day. One is removed at a time, cleansed, boiled, and returned carefully into the track from which it was removed. No useful purpose is served by forcibly syringing up the tubes or tracks and trying to make the fluid come out of the meatus or go into the nose !

When the tubes appear to be pushed out, they can be shortened gradually. Generally one tube should reach to the antrum as long as meatal otorrhœa persists.

Secondary suture of an unclosed wound.—After the temperature has been normal for a fortnight, the surgeon may close a wound which has broken down or been intentionally packed to keep it open up to this stage.

In patients weakened by infection, with tissues fragile and feeble in reparative power, and particularly in children, a delay of four or six weeks may be allowed before undertaking the secondary closure of the wound, and then it should only be done if healing is far from complete, or to correct disfigurement.

If, in spite of a satisfactory mastoid operation, otorrhœa should persist for some weeks, the surgeon must seek and remove the cause. A simple mastoid should not be prematurely converted into a radical mastoid operation ; it may be better to prolong the mastoid antral drainage (i.e. not to remove the antral drainage tube before the meatal otorrhœa ceases), seek and deal with any possible cause of infection in the nose and pharynx, and pay careful regard to the general health. Post-aural tube drainage was maintained for nearly twelve months in one patient with entirely satisfactory results. During this period the original wound was re-explored, and no cause for failure discovered apart from chronic rhinitis (non-sinusitic). The alternative was to consider conversion to a radical mastoid operation (*see* below) which was avoided by the prolonged post-aural drainage. The drum membrane healed, and hearing became normal. Postoperative persistence of discharge is sometimes due to infection of a pneumatized apex of the petrous bone, that is, to infected cells in front of the cochlea, or to perilabyrinthine cells—conditions which present special problems to the surgeon.

THE RADICAL MASTOID OPERATION

Essentially, the so-called radical or complete mastoid operation is an extension of Schwartze's procedure. It includes resection of the outer attic wall, and removal of the malleus, incus, and tympanic membrane, or of the remains of these structures which have escaped destruction by disease or injury (Stacke).

As a sound general rule, the radical operation is only justifiable, in place of Schwartze's, when other means of arresting suppuration in the tympanum, including the operations for overcoming infection of nose, nasal sinuses, and naso-pharynx, and tonsillectomy, have failed or are not indicated, and when useful hearing is already permanently lost.

In acute or recent otitis media it is not right to perform the radical operation in preference to Schwartze's, unless there is *unmistakable* objective evidence that the labyrinth is invaded and that the patient's life is in imminent jeopardy.

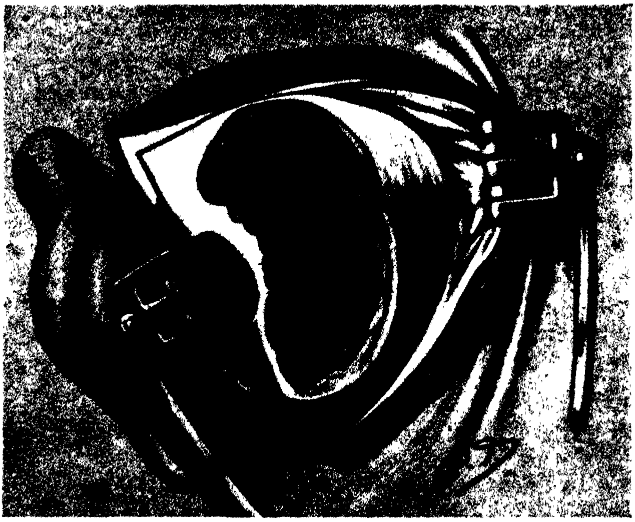

Fig. 618.—Epitympano-mastoid operation, first stage.

Cases of otitis media with infection of the sigmoid sinus have recovered completely after Schwartze's operation and drainage of the sigmoid sinus, without recourse to the radical operation. A child with tuberculosis of the lateral sinus recovered with no recurrence of tuberculosis or of middle-ear disease. The perforation of the tympanic membrane healed, and hearing was little short of normal, which would have been impossible had the radical operation been performed. Similarly satisfactory results are repeatedly encountered in cases of recurrent and prolonged suppuration. It is also possible to avoid the *radical* mastoid operation in *acute* otitis media complicated by brain abscess and certain forms of lepto-meningitis, provided the mastoid and abscess are drained.

Technique.—**First stage : completion of Schwartze's operation.**—The operator completes that part of the mastoid operation which involves removal of the mastoid cortex (*see* p. 1294).

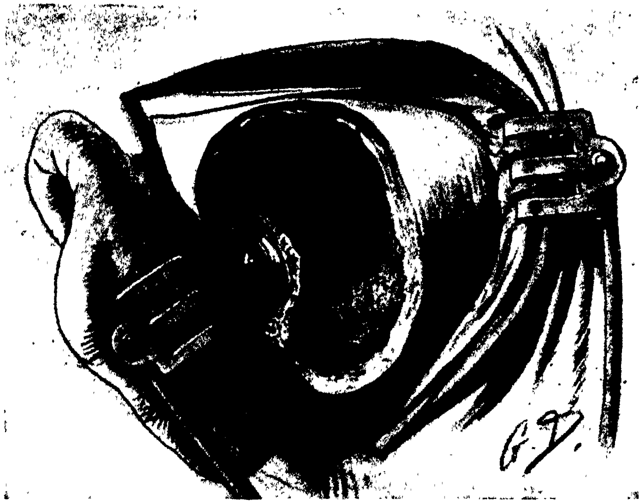

Fig. 619.—Epitympano-mastoid operation, second stage.

Second stage : exposure and removal of osseous meatal wall.—The self-retaining retractor is opened out as the cuto-cartilaginous meatus is detached. The chief assistant, with gauze strips or small wool swabs, absorbs any blood which obscures the osseous meatus, and the operator removes the posterior wall with gouge and hammer, in

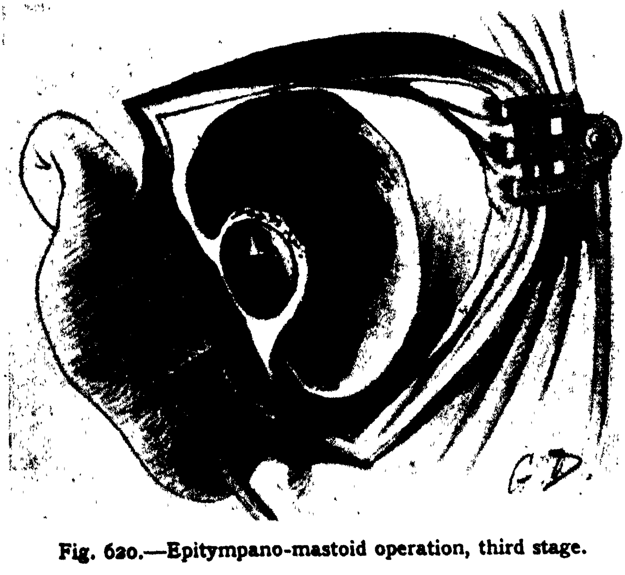

Fig. 620.—Epitympano-mastoid operation, third stage.

order to display the bony bridge which arches over the upper attachment of the tympanic membrane. A rectangular seeker may be passed from above, over the bridge into the aditus and attic, to enable the surgeon to determine the dimensions of the outer attic wall.

Third stage : removal of outer wall of attic.—This can be removed with three cuts with the gouge. A small shallow gouge is selected. (Fig. 610, 4.) The first cut is parallel with the tympanic ring ; the second and third are respectively in front of and behind the malleus, and almost radial to the tympanic ring. These three cuts should isolate a small wedge-shaped fragment of bone, which is picked out with forceps. The aditus and attic, now in view, are exposed more freely by chipping away surrounding ledges and overhanging bone. The surgeon will cut only what he can see, and this will depend considerably upon his assistant's control of the oozing, which otherwise would obscure the field. An electro-motor suction apparatus is sometimes of great service in clearing the field of blood.

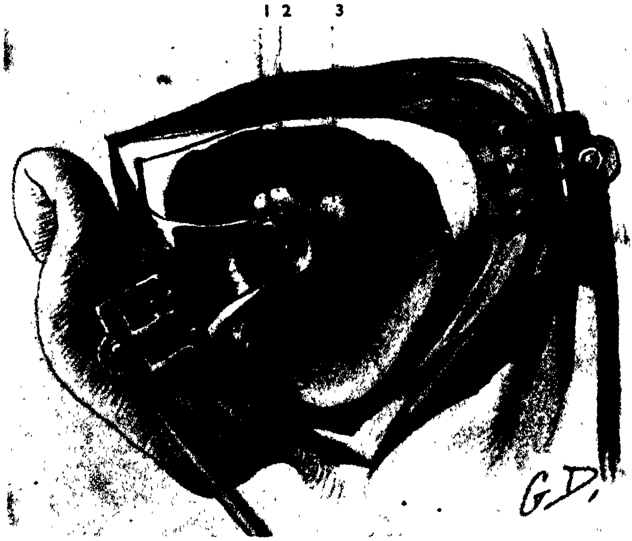

Fig. 621.—Epitympano-mastoid operation, fourth stage.
1, Malleus : 2, incus ; 3, eminence formed by external semi-circular canal.

It is at this stage that the facial nerve is especially endangered, and the greatest care must be taken to avoid injuring it.

Fourth stage : removal of ossicles, etc.—The incus and malleus, or their remains, are picked out with forceps. With a small curette the operator removes the bloodclot, granulations, and cholesteatomatous epithelial débris which may be present, and in doing so must beware of damage, especially to the facial nerve, the stapes, the jugular bulb, and the internal carotid artery. These four structures have been injured at various times. Fatal leptomeningitis following operations on the tympanum has been caused by dislocation of the stapes and labyrinthitis, and it is an important rule never to curette *towards* the inner tympanic wall.

In two out of three cases of *very chronic* middle-ear disease which come to operation, no incus can be discovered, and the head of the malleus is then generally eroded. Not very rarely the malleus has completely disappeared. In these cases of diseased ossicles the surgeon has no cause for regret at having performed the radical operation, but it occasionally happens that the incus and malleus, after extraction, are found to be absolutely normal in themselves, though surrounded by granulations or swollen mucosa. As there appear to be no very certain means of distinguishing these cases, a conservative course is recommended, for it will generally be a cause for misgiving when the surgeon finds that the ossicles and their articulations are unaffected. He should feel concerned that nothing short of their removal had enabled him to discover the absence of destructive osteitis or arthritis, and it is certainly worth the closest attention to seek some definite evidence of ossicular destruction before exposing or removing the auditory ossicles, or running the risk of breaking an intact ossicular chain. To this end the hearing test with Bezold-Edelmann or similar forks is of practical value. The radical mastoid operation is contra-indicated when hearing is retained for low tones, i.e. below 36 and 55 double vibrations per second.

In a case open to doubt, even where hearing is very defective, it is certainly permissible to watch the effect of Schwartze's operation before advising conversion to the epitympanic operation or to the radical operation. Where tympanic suppuration persists, in spite of satisfactory mastoid drainage and freedom of the nose and pharynx from infection, and when hearing is beyond hope of recovery, the surgeon can seldom advocate conservation of the tympanum.

Figs. 618–621 illustrate the principal stages of the epitympano-mastoid operation, which is applicable to cases of chronic disease of the antral region unassociated with gross destruction of the drum-membrane and ossicles.

Fifth stage : plastic stage and provision for drainage.—Whereas the cavity formed in Schwartze's operation is drained through the primary skin incision, some modified system of drainage is introduced in the radical mastoid operation.

In the radical operation without intracranial involvement, complete closure of the postaural incision is now the rule, though this was not so formerly. As Ballance pointed out in his original paper over forty years ago, it is an advantage to divide the posterior meatal wall and throw the mastoid and tympanic cavities and external meatus into one common compartment.

This enlargement of the meatus is in no sense an essential part of the radical operation, though almost universally practised. A similar procedure—namely, section of the posterior meatal wall with consequent expansion of the meatus—can be applied to Schwartze's operation, as introduced by Küster, and adopted by other aural surgeons (e.g. Heath's operation).

Section of the meatal wall and formation of a flap of skin, which is turned aside, is an expedient to render the mastoid-operation cavity accessible to inspection from the external auditory meatus; it also hastens the growth of epithelium lining the cavity. It is obvious that no flap can be fashioned from the meatus or concha alone to clothe the entire tympano-mastoid cavity; an up- or down-turned flap will cover only a portion of the surface of the operation cavity; the rest must heal by second intention—the formation of granulations followed by epidermatization, often a slow process unless skin-grafts be applied (*see* p. 1303).

The meato-conchal flap.—It matters little whether the meato-conchal flap be turned upwards or downwards. Much depends on the size and shape of the mastoid cavity which has been made.

The up-turned flap.—The blade of the narrow scalpel is introduced into the meatus, cutting edge downwards, and an incision is carried through the skin along the floor as far outwards as the concha; it then sweeps upwards across the concha as far as the crus of the helix above the meatus. The size of the new-formed meatus depends upon how far the incision is carried into the concha and crus. Usually, ⅛ in. behind and concentric with the posterior margin of the meatus will give a sufficiently large opening, without producing an unsightly enlargement. Care should be taken to prevent stenosis, which sometimes results from removing too little cartilage from the concha.

The section forms a meatal flap of skin and cartilage, the latter being dissected out and detached while the pinna is held forwards. Only skin need be preserved, and this should be thin so as to lie smoothly against the roof of the operation cavity. A catgut suture or two is sometimes necessary to secure the outer corner of the flap in position. Branches of the postauricular artery are divided and will generally require ligaturing.

The down-turned flap.—Instead of dividing the floor of the meatus, the surgeon may make the incision along the roof, thence into the concha, and downwards to the lower outlet of the meatus. The skin-flap is freed from the fibro-cartilage as before, and the thin layer of skin turned downwards, instead of upwards. No suture is required, and sometimes the postauricular artery is avoided.

Some surgeons prefer to make the incision along the posterior meatal wall, with a T-incision in the concha; two narrow flaps are then up- and down-turned. The device appears to be devoid of any essential advantage.

Thiersch skin-grafts.—It was to hasten and complete this epidermatization that Ballance introduced the application of Thiersch skin-grafts for cases of radical mastoid operation.* A period of ten days or so was allowed to elapse between the radical operation and the application of the graft, which is now introduced as a routine at the time of the radical operation.

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* *Trans. Med.-Chir. Soc., Lond.*, 1900, lxxx, 3.

Contra-indications to graft.—Should some intracranial complication, such as extradural abscess, lateral-sinus infection, or brain abscess, be discovered, or the labyrinth be involved, the application of the graft is usually omitted or postponed.

Technique of Thiersch grafts (*see also* p. 1638).—The skin-graft for the mastoid is usually taken with a razor from the inner surface of the thigh or from the upper extremity. The razor should have a *straight* edge. The graft should be about 8 in. by 2 in. and free from " button-holes." Different methods have been employed to spread the graft after introducing it into the mastoid cavity. Ballance's method is well known ; he employed a suction apparatus, aspirating the blood which separates the graft from the granulation surface. Other surgeons prefer to manipulate the graft in position with forceps and directors, and apply small pledgets to keep it temporarily in place. Some employ a pleated gauze strip, or wick of coarse cotton strands, on which the graft is spread, and the plug is introduced into the cavity *en bloc*. The narrowest single layer ribbon gauze or wick of cotton strands should be impregnated with Bipp paste, to avoid the fœtor otherwise associated with skin-grafts in radical mastoid operation cavities. An undoubted advantage of Bipped cotton wicks is that they can, with care, be withdrawn one by one, so as to avoid pain in after-dressings. The postaural incision is then closed with three or four separate fishing-gut or catgut sutures, or Michel clips. Dry dressings are applied and secured with a narrow 2-in. occipito-frontal bandage.

The graft is, of course, quite uncalled for in Schwartze's operation, where postaural tube drainage is employed without section or enlargement of the meatus, and it is hardly required in Küster's operation for *acute* otitis media ; but when a meato-conchal flap has been cut, as in Küster's modification of Schwartze's operation for *chronic* disease, a graft may be applied.

After-treatment.—Absolute uniformity in after-treatment cannot be expected. Vaselined dressings are painlessly removed.

The outer dressing may be removed in twenty-four hours, and a little of the packing loosened and withdrawn. Each day three or four inches, more or less, of packing, or several cotton strands, are withdrawn, until by the end of the fifth or sixth day—possibly sooner—all packing has been removed from the cavity. No fresh packing is introduced during the first ten days.

In the second week there is generally more discharge than in the first, and it is then often advisable to syringe the cavity morning and evening with normal saline. Care is necessary to see that the fluid is approximately at the body temperature, because after the radical operation the labyrinth is more exposed to thermal changes, with consequent giddiness, and often sickness and faintness.

By the third week all shreds of skin-graft have generally been washed away or removed, but there may be granulations here and there. If the latter become very soft and œdematous, it is sometimes advisable to insert ribbon gauze packing, changing it daily. If the granulations are exuberant at the cut edge of the concha or of the meatal incision, the application of chromic acid, fused on a silver probe, is recommended to prevent stenosis of the newly-formed meatus.

The ultimate success of an operation often depends upon the care with which the surgeon controls the overgrowth of granulation tissue. Only too frequently a patient on whom a mastoid operation has been perfectly performed has been lost sight of until the whole cavity has become *filled* with granulations and synechiæ, all because precautions to limit the growth of redundant granulations during the first few weeks were omitted.

The patient can usually be allowed up by the fifth day, and may go out of doors in suitable climates after the twelfth day. Hospital patients usually become out-patients in the third week. With regular syringing the cavity generally heals completely in six to eight weeks. In a very few exceptional cases cavities have become dry within two weeks, and have remained dry and healed perfectly. On the other hand, some cases are very intractable, and epithelialization is incomplete even after several months, even though all cells and caries have been eradicated. Such cases raise a suspicion of overlooked foci of infection, the most frequent being some form of postnasal catarrh, perhaps an obscure sphenoidal-sinus infection.

It is interesting to observe the effect on suppuration in the ear of freeing the nose and pharynx from infection, and the surgeon should constantly keep the upper air-passages under his observation if he is successfully to counter persistent aural discharges after mastoid operations. He will be wise, for instance—to take a common example—to reverse the former practice of postponing the removal of the tonsils till the ear ceases to discharge, except in cases of emergency.

OPERATION ON THE INTRACRANIAL SINUSES FOR INFECTIONS OF OTITIC ORIGIN

The operation for infective thrombosis had been proposed, though not practised, in Germany, and it was reserved to Sir William Arbuthnot Lane[*] and Sir Charles Ballance[†] some ten years later, to be the first surgeons to operate successfully for this condition. In their 14 cases there were 9 recoveries, the previous mortality having been practically 100 per cent. The technique is now such that the destiny of the patient may be said to depend primarily upon the early and accurate recognition of the disease, and secondarily upon prompt and timely surgical intervention. Physicians and medical practitioners called to cases of acute or chronic ear disease are more than justified in thinking of the probable implication of the intracranial sinuses the first moment the patient's temperature runs high.

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[*] Clinical Society of London, April, 1889.

[†] Medical Society of London, March, 1890. "On removal of pyæmic thrombi from the lateral sinus," May 17 and 24, 1890, i, 1057, 1114 (full paper with bibliography).

Pathological considerations.—The following classification comprises the usual and various complications which arise from intravenous infection due to otitis media:

- (1) Septicæmia, independent of thrombosis of the intracranial venous sinuses or internal jugular vein.
- (2) Thrombosis of the sinuses and/or jugular vein—
    - (*a*) With neither local intravenous nor systemic infection.
    - (*b*) With local but not systemic infection.
    - (*c*) With local and systemic infection, e.g.:
        - Endocarditis.
        - Pneumonia.
        - Thoracic empyema.
        - Abdominal visceral infection.
        - Suppurative arthritis.
    - (*d*) With local infection and cerebellar abscess.
    - (*e*) With local infection, leptomeningitis and encephalitis.
    - (*f*) With local infection and cavernous-sinus thrombosis.

Septicæmia and Sinus Thrombosis

Although septicæmia occasionally occurs in acute otitis media without manifest signs of any localized infections of the great venous channels, a more circumspect examination of the adjacent sinus and jugular bulb will sometimes reveal a localized area of endophlebitis,[*] which certainly antedated the fatal systemic infection. Generally a coagulum of cells and fibrin from the blood-stream forms and adheres to the inner wall of the sinus at the seat of the attack. Its function is evidently to form a barrier. When this succeeds, and organisms invade neither blood-stream nor mural clot, the latter becomes organized and blends with the sinus-wall, and no clinical manifestations are observed. If virulent organisms raid the blood-stream before a thrombus forms, or portions of the infected thrombus become detached, the clinical picture of septicæmia at once begins. When the adherent coagulum vigorously resists the attack, it is reinforced by more and more fibrin and cells hastily precipitated by the passing stream; the new clot adheres to and surrounds the first-line barrier, and as this yields to the infection, so the thrombus grows and extends up and down and around the vessel-wall; at last the whole stream becomes blocked by this mass, which may reach up to the longitudinal sinus and down to the right chambers of the heart. But before the venous channel is blocked to this extent, the first-formed clot has completely succumbed, become disorganized, disintegrated into a necrotic and purulent state; it is now yellowish-green, with some particles quite black. At this stage the clinical picture may still be one of a localized infection, severe as it is, with moderate remittent pyrexia.

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[*] *See* case of malignant endocarditis following streptococcal otitis media; localized endophlebitis of sigmoid sinus without thrombosis (West and Scott's "Operations of Aural Surgery," p. 128).

Should the outer wall of the sinus slough away, and the purulent remnants of the clot escape externally, the systemic circulation may be saved, with the sacrifice of the venous channel alone.

But during the earlier stage of the process, particles of infected fibrin may become detached and whirled along in the blood-stream, setting up metastatic foci in heart or lungs, or infecting the abdominal viscera and more remote parts of the body. Then is it that the patient has rigors, with great intermissions of temperature ; and the manifestations of metastasia may become more evident than the original focus of infection. Endocarditis, pericarditis, pneumonia, thoracic empyema, abdominal signs closely resembling those of typhoid fever, or suppurating arthritis may predominate. A metastatic abscess in the brain may complicate the clinical picture.

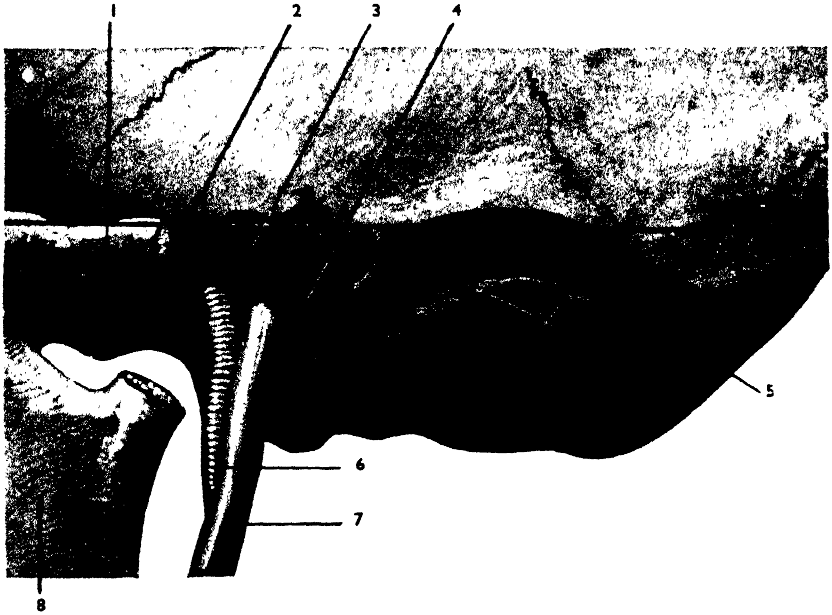

Fig. 622.—Topography of middle-ear cavity in relation to internal carotid artery, lateral sinus, and jugular vein.

1, Zygoma ; 2, Eustachian tube ; 3, tympanum ; 4, mastoid cells ; 5, lateral sinus ; 6, internal carotid artery ; 7, internal jugular vein ; 8, ascending ramus mandible. Horizontal line, infraorbital zygomatic plane.

Apart from metastasia, the original infection within the sinus may penetrate its inner wall, causing a localized intradural or intracerebellar abscess. Or the sepsis may spread either along the tentorial venous tributaries, leading to widespread purulent pia-arachnoiditis and encephalitis, or along the petrosal tributaries, implicating the cavernous sinus, the ophthalmic veins and the facial veins.

So long as the infection is confined to the sigmoid sinus, there is no characteristic symptom of its location, but there is always at least moderate *pyrexia*, which is a danger signal in otitis media. It is unnecessarily risky to watch until the temperature chart shows daily excursions of 4–8° F., often with *rigors*, which have been generally regarded as pathognomonic of sinus thrombosis. For by this time the case is already one of infective metastasia or septicæmia.

When pyrexia cannot be completely explained by some other disease than that of the ear, the safest course is to expose the infective focus and adjacent sinus-wall.

Having found the seat of infection, the surgeon has two definite objectives before him :

(1) The removal of all septic matter in the bone and adjacent venous channel.

(2) Maintenance or establishment of permanent barriers between that part of the venous channel involved and the general systemic circulation.

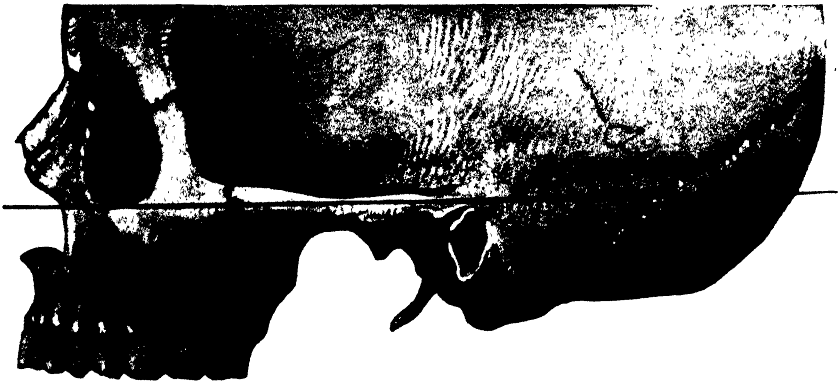

Fig. 623.—Lateral aspect of skull to show *infraorbital zygomatic plane* (indicated by horizontal line—" Frankfort Line ") and relation to lateral sinus, the position of which varies between the dotted lines.

To achieve the latter, it may be necessary to ligature the internal jugular vein.

In the course of the mastoid operation for *acute* otitis media, the disclosure of an unexpected extradural perisinus abscess immediately raises the suspicion of possible thrombosis.

If the pyrexia and general state of the patient can be explained by the extradural abscess alone, the surgeon is justified in waiting for a day or two before deciding whether or not to explore the sinus. Red granulations on the sinus-wall generally indicate a lively process of local resistance ; but a dark or greenish hue indicates that the sinus-wall should be laid open and explored without waiting for clinical evidence of sinus infection.

If the pyrexia does not recede within forty-eight hours of the mastoid operation, when granulations over the sinus wall have been seen, even if there be no rigor, the wound should be *re-opened* and the sinus re-exposed and laid open by incision with a scalpel or, if there has been a rigor or two, or sudden rise of temperature to 103° or 104° F. alone, it may be justifiable to explore and to tie the internal jugular vein in the first place, before proceeding to open the sinus, the objects being (1) to confirm the diagnosis of thrombosis ; (2) to arrest particles of detached thrombus, due to manipulation of the sinus.

Until considerable experience has been attained, it is safer always to tie the vein. In the complete absence of signs of systemic metastasia, the operator need not tie the vein if the thrombus does not reach the jugular bulb. Experience will help him to decide when he need not do so, but it is safe to say that he will not regret having ligatured the vein.

Technique of operation on the lateral sinus.—The patient having been anæsthetized and the field of operation on the head and neck shaved and prepared with all customary aseptic precautions, the operator stands on the side to be operated upon, with his assistant at the end of the table and the anæsthetist on the opposite side.

The mastoid operation is performed as described at p. 1292. To expose the lateral sinus it is necessary to divide the scalp and pericranium from the middle of the original mastoid incision, backwards along the superior curved line of the occipital bone.

The squamo - parieto - mastoid sutures are exposed with the periosteal separator, bleeding from vessels in the scalp is arrested with Spencer Wells or with T-forceps (Sargent's) (Fig. 624), and the retractors introduced. The bone can now be removed with ¾ in. gouge and hammer in thin flakes along the course of the lateral sinus and sigmoid sinus. When the dura mater is exposed the cranial opening is enlarged with bone-cutting forceps (Fig. 625) to expose two-thirds of the lateral sinus in a backward direction, and the superior genu, inferior genu and transverse portions of the sigmoid sinus are exposed towards the jugular foramen.

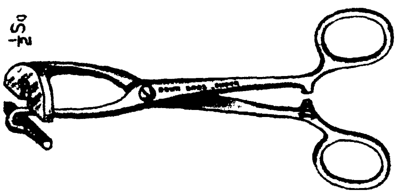

Fig. 624.—Sargent's T-forceps.

Before opening the sinus it is advisable to anticipate bleeding and exert pressure on its outer wall by introducing Bipped gauze plugging between the adjacent unexposed portion of the sinus and the occipital bone. The sinus having been prepared for exploration, the thickened or discoloured part of the wall is cautiously incised, using first a scalpel, then scissors, to open a length of the sinus. The clot can be picked out with forceps in many cases, in some it is removed only with the aid of a curette. Suction with the electro-motor pump is also effective in removing pus, débris and clot.

When the terminal part of the clot is withdrawn from the occipital end, any blood escaping is much less than if preliminary gauze plugging were omitted, and is the more easily controlled by temporary digital pressure. When this is not adequate to stop the flow, a small gauze strip must be introduced quickly on to or even into the sinus itself, or a piece of muscle or a small fascial sheet can be applied to the sinus wound and packed in place with Bipped gauze or cotton wick.

The advantage of using Bipped gauze is that it can safely be left undisturbed for 7 or 8 days. Hæmorrhage from the sinus above the clot being now under control, the entire outer wall of the sinus is excised with curved scissors as far as its entrance to the jugular bulb. Moderately free hæmorrhage from the jugular end may be taken to indicate that the jugular bulb is not occluded.

Profuse bleeding from this end rarely occurs and is easily arrested by packing. Should pus and débris be found to ooze up from the jugular end of the transverse sinus, the internal jugular vein must be exposed, ligatured, opened, and drained.

The upper two-thirds of the mastoid wound over the lateral sinus may be sutured, allowing the ends of the Bipped packing to protrude.

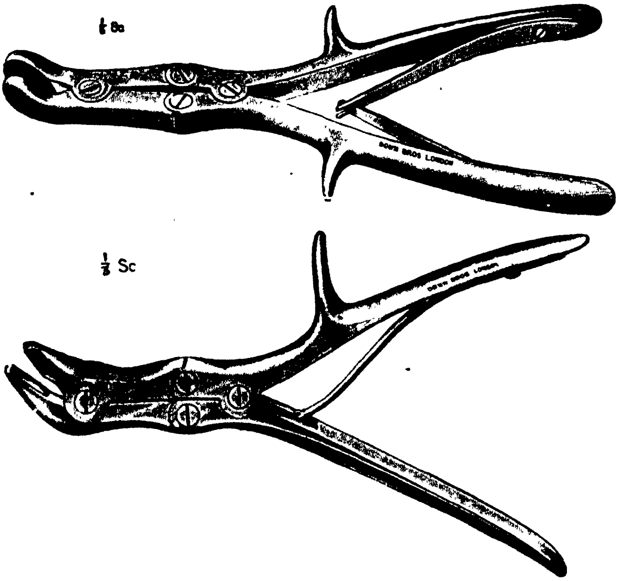

Fig. 625.—Double-lever craniotomy forceps.

The packing is gradually withdrawn inch by inch during the subsequent eight days, when the last piece, which compressed the sinus, comes safely away. Care is taken to pleat the gauze at the time of insertion, and to leave the end projecting in such a manner as shall ensure easy and painless removal. It is not safe to remove the last piece of plugging before the eighth day.

Special points in ligaturing the internal jugular vein for sinus infections.—The skin of the neck and upper front of the chest is prepared as for other operations, and a narrow sand-bag is placed beneath the lower part of the neck and shoulders. The head wound is temporarily covered with dressings, and the internal jugular vein is exposed through an incision not less than three inches long, starting at the angle of the jaw and running parallel with the anterior border of the sterno-mastoid muscle. In several cases a curved horizontal incision about the level of the hyoid bone has given ample access to the vein, and has the advantage of leaving a less noticeable scar. The internal jugular vein is traced upwards beneath the parotid gland, and subsequently downwards towards the subclavian vein, when necessary. Probably some enlarged lymphatic glands will be encountered before the vein can be found, and they may have to be removed to isolate the vein. Generally the largest tributary to the internal jugular is the common facial vein.

The internal jugular vein will often be found collapsed. Two ligatures are applied, and the vein divided between them. Its upper portion is freed towards the skull, all tributaries being separated and ligatured *en route*. If the vein feels thickened, it may contain clot, and must be handled with extreme care until securely ligatured on the cardiac side of the clot.

The cephalic end of the vein is opened and the clot extracted, a small curette being introduced up the vein as high as the jugular bulb, if necessary. The vein itself may then serve as a drainage-tube, by being secured to the uppermost end of the skin-incision, as Alexander and Ballance advocated.

The cervical wound is now closed, a drainage-tube being provided at the lower or outer end, and dressings applied to the neck.

The operation advocated by Grunerts, who exposed the bulb in direct continuity with the transverse sinus and jugular vein, is seldom justified.

The radical mastoid operation.—No mention has been made of the radical mastoid operation in lateral-sinus infection. We are dealing with infective sinus thrombosis in primary *acute* otitis media. There is so far no indication for destroying the tympanic structures, and we are anticipating recovery of the patient with complete return of hearing.

The more frequent occurrence of infective thrombosis in the course of *chronic* otitis media will be referred to later, but so far as the operations on the venous channels are concerned, the procedure is the same in both cases ; the radical mastoid operation would be performed, not because the venous sinus is involved, but because of the changes wrought in the tympanum by chronic disease.

INTERNAL EAR : OPERATIONS ON THE LABYRINTH

LABYRINTHITIS

Although operations on the labyrinth belong to a special branch of surgery, it is important that the general surgeon should be familiar with the conditions for which they should or should not be undertaken.

Vertigo and vomiting in a patient suffering from otitis media, whether acute or chronic, should call for immediate investigation to ascertain whether the giddiness is due to infective invasions of the labyrinth, or merely to congestive pressure or other less important, but common, causes of temporary labyrinthine disturbances without actual invasion or destruction of the internal ear itself. The frequency and rapidity with which leptomeningitis follows infective labyrinthitis, and the knowledge that this form of meningitis can be prevented or arrested by immediate drainage of the labyrinth, are sufficient reasons for dwelling upon the great importance of early and accurate recognition of this complication of middle-ear disease.

When middle-ear suppuration is present *vertigo, reeling gait,* and *vomiting,* associated with *nystagmus,* may be due, in order of frequency : (1) to disturbances in labyrinthine function caused by pressure or congestive changes in the middle ear, which interfere through the fenestræ with the labyrinth pressure without destroying the neuro-epithelium ; (2) to infection and acute inflammation and consequent destruction of the labyrinthine neuro-epithelium (panlabyrinthitis) ; (3) to gradual destruction of the osseous labyrinth and formation of a fistula of the external semicircular canal ; (4) to cerebellar abscess.

In investigating such cases, after otitis media has been diagnosed, the surgeon decides whether panlabyrinthitis is present or not. In panlabyrinthitis the patient suffers from permanent absolute deafness as well as giddiness and nystagmus of prolonged but temporary duration. Having made certain that the patient is absolutely deaf on the affected side, the examiner must ascertain whether the vestibular labyrinth has lost its normal sensibility to stimulation by applying the caloric or thermal test. (Fig. 626.)

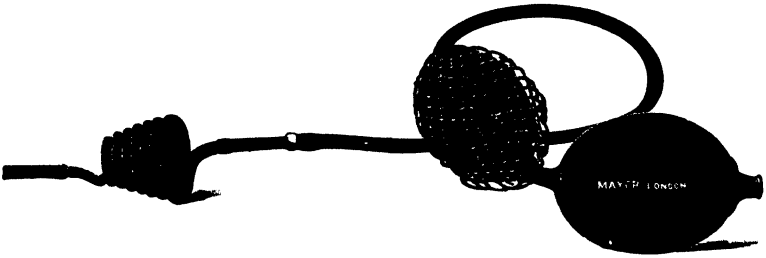

Fig. 626.—Dundas Grant's apparatus for cold caloric test—a continuous current of cool air is blown into the external auditory meatus.

It is important to remember that there are other forms of vertigo and other causes of headache in ear diseases besides actual infection of the labyrinth, and that the diagnosis of labyrinthine infection must not be made unless the caloric tests have been carefully applied, and definite negative reactions obtained. At the same time, the surgeon must satisfy himself that polypi, granulations, and débris in the external or middle ear are not responsible for negative reactions by preventing the conduction of thermal influences to an intact labyrinth.

It is also most important to realize that inequality of pressure in the tympanum of either side will, in certain circumstances, cause nystagmus and vertigo in subjects with normal labyrinths.

Acute otitis media is often accompanied in the initial stages by sensations of giddiness, and sometimes by spontaneous nystagmus, but normal reactions are evoked by the caloric tests. These symptoms soon disappear after myringotomy in cases where tympanic hypertension is responsible.

Diffuse labyrinthitis.—When the whole labyrinth is invaded spontaneous nystagmus will be observable when the eyes deviate towards the opposite side.

Localized labyrinthitis.—In cases of chronic middle-ear disease, an erosion of the external semicircular canal sometimes takes place.

The "fistula symptom."—The classical sign of labyrinthine fistula is evoked by sudden but gentle pressure applied to the meatus. The eyes jerk horizontally to and fro, the movement ceasing in a few seconds, to re-appear every time the compression is re-applied. The fistula symptom ceases directly the membranous labyrinth becomes destroyed.

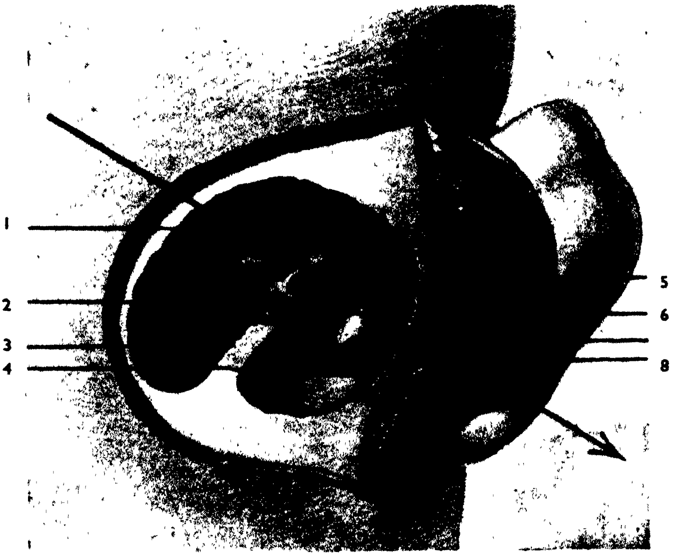

Fig. 627.—Vestibulotomy, first stage.

1. Inner wall of antrum; 2, Fallopian aqueduct; 3, floor of mastoid-operation cavity; 4, posterior wall of osseous meatus; 5, external semicircular canal; 6, fenestra ovalis; 7, promontory of cochlea; 8, fossula rotunda. The arrow indicates an imaginary line which crosses in succession the antrum, external semicircular canal, facial nerve, fenestra ovalis, cochlear promontory and Eustachian tube.

Labyrinthine fistulæ which give rise to no special symptoms immediately before the operation may be unexpectedly discovered in the course of a mastoid operation, and it is important to know whether the fistula should be opened up and explored, or left alone. Any unsuspected fistula discovered in the course of a radical mastoid operation should not be opened up unless the hearing and caloric tests yield negative reactions.

Extirpation of the labyrinth.—*Partial* or *inferior vestibulotomy* consists in opening the vestibule from the tympanum below the geniculate ganglion of the facial nerve. (Fig. 627.) Its object is to effect drainage of the cavity of the labyrinth and to remove the membranous contents. The cochlea would be necessarily involved, and no useful hearing be present.

The more *complete* or " *double* " *vestibulotomy* combines with inferior vestibulotomy a counter-opening above and behind the second part of the facial nerve. (Fig. 628.) This counter-opening is made into the external semicircular canal either at the site of an existing fistula, or else through an artificial opening made by removing the eminentia arcuata externa with the gouge and following along the external crus of the semicircular canal into its ampulla ; thence, by working upwards, the ampulla of the superior semicircular canal is opened, and the angular projection of dense bone in the posterior part of the roof of the vestibule is chipped off. There is great danger of injuring the facial nerve, and to guard against this the surgeon must be absolutely familiar with its topography and accustomed to the use of small gouges and hammer. A burr is not recommended. In performing these difficult operations he depends largely on uninterrupted illumination and careful and experienced assistance. Zeiss operating lenses may be useful in some cases.

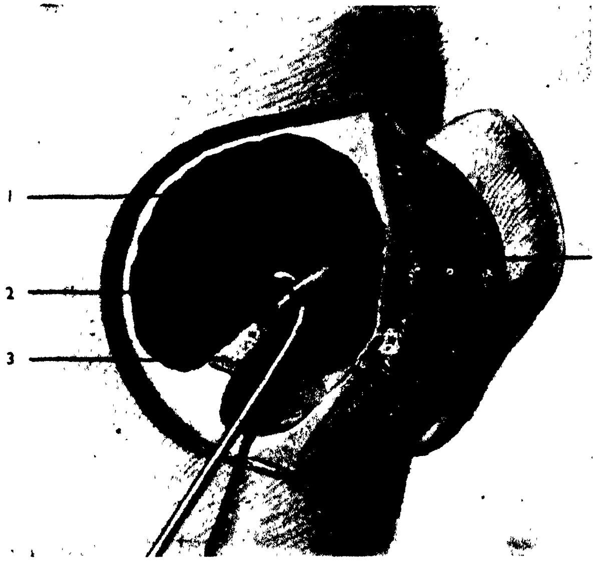

Fig. 628.—Vestibulotomy, second stage.

1, Inner wall of antrum ; 2, seventh nerve ; 3, base of posterior meatal wall ; 4, opening into vestibule above facial nerve, through external semicircular canal. The hook is passing into the vestibule around the mesial side of the seventh nerve.

Technique of operations on the labyrinth. (*See* Fig. 629.) **Stage 1.**—This consists of the radical mastoid operation.

Stage 2 consists in opening the vestibule below the facial nerve. A small gouge is selected and inserted in the pelvis ovalis. By repeated slight taps with a hammer, the gouge is successively rotated, until the first crescentic cut is extended into a circle enclosing the whole of the outer wall of the vestibule below the geniculate ganglion of the facial nerve. With the aid of seeker and curette, the encircled fragment of bone is removed, and the lowest whorl of the cochlea and floor of the vestibule are exposed and the foramen rotundum is destroyed.

Stage 3.—In acute labyrinthitis the membranous labyrinth often separates in one mass of intensely hyperæmic membranous tissue. Bacteriologically, it will be found to be swarming with streptococci or other organisms. Unless it is intended to explore the internal auditory meatus, it is not advisable to curette the antero-internal wall of the vestibule, or the base of the modiolus of the cochlea, though the internal meatus can be opened deliberately in certain cases to allow cerebro-spinal fluid to escape (*see* below).

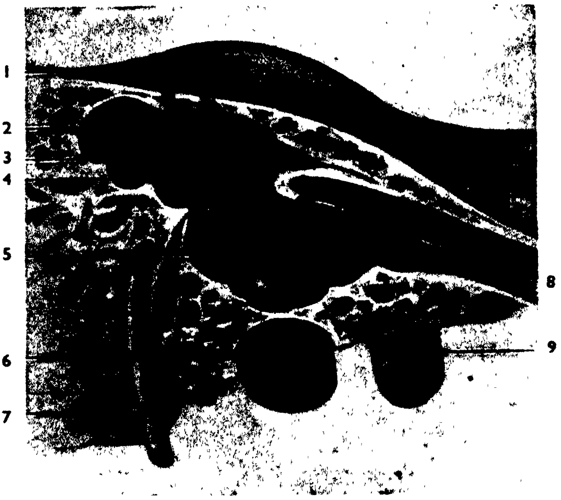

Fig. 629.—Lateral vertical section of temporal bone through tympanum, to show relative position of labyrinth.

1, Superior semi-circular canal; 2, posterior ditto; 3, external ditto; 4, vestibule; 5, cochlea; 6, internal jugular vein; 7, facial nerve; 8, Eustachian tube; 9, internal carotid artery.

Extirpation of the cochlea.—This operation is undertaken as an extension of vestibulotomy in cases of tuberculosis or of malignant disease. The proximity of the internal carotid artery immediately beneath and in front of the outer coil of the cochlea must not be forgotten.

Leptomeningitis Secondary to Labyrinthitis

Leptomeningitis is the most fatal complication of otitis media. Patients in whom pus in the labyrinth is overlooked often die of leptomeningitis, and unless at the autopsy the labyrinth is deliberately examined, no one may be aware of this path of infection from the tympanum to the membranes of the brain. Many cases of basal meningitis have been proved to be due to purulent labyrinthitis. The only special operations for leptomeningitis considered here are translabyrinthine drainage and repeated lumbar puncture.

Translabyrinthine drainage is limited in its application. The actual onset of meningitis may be difficult to determine, and the diagnosis of this complication is not justified unless there are severe headache, head retraction, Kernig's sign, and the discovery, by lumbar puncture, of cerebro-spinal fluid under excess pressure and having abnormal constituents. Where labyrinthitis is known to be present, and meningitis suspected, diagnostic lumbar puncture should be performed at once. If the fluid is obviously under excess pressure or turbid, translabyrinthine drainage is recommended. When the labyrinth is infected, the meninges are especially exposed to the rapid extension of infection along the prolongation of the arachnoid sheath, common to the 7th and 8th nerves, which leads to the cisterna pontis close to the cornucopia of the 4th ventricle. (Fig. 630.) As soon as the infection invades the canal of the internal meatus, leptomeningitis has commenced. It was to drain these spaces and meshes of the meninges, which are the earliest involved, that the translabyrinthine route was first designed and practised. The recognition of the anatomical and pathological facts led to a trial of the operation, and the results have demonstrated its efficiency in suitably selected cases. Unfortunately, the surgeon may not be called to see the patient until it is too late, and he may find the internal meatus already obstructed by swollen tissue at the ponto-cerebellar angle, so that the infected cerebro-spinal fluid cannot escape. In such cases the only measure of

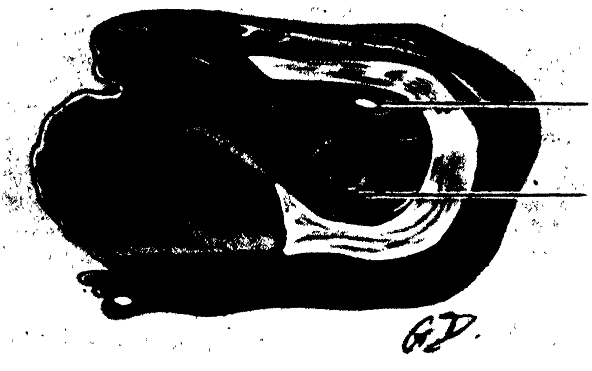

Fig. 630.—Fundus of internal auditory meatus viewed from cranial cavity, to show entrance to Fallopian aqueduct (1) for facial nerve above, and entrance foramina for fibres of cochlear portion of auditory nerve below (2).

practical value is lumbar puncture repeated every twelve, eighteen, or twenty-four hours, according to the results and progress of the case.

In meningitis serosa the cerebro-spinal fluid may not appear to be turbid, and no organisms may be isolated, yet sudden death by pressure on the respiratory centre may follow a very short period of drowsiness or coma (less than one hour). If during the comatose state the pressure is relieved and its recurrence prevented, the patient may survive; but where there is an accumulation of fluid in the lateral recess and in the cisterna pontis, which is locally infected, repeated lumbar puncture alone will not arrest the extension of the infection to the neighbouring meninges. The object of translabyrinthine drainage is therefore to remove the local infection and release the cerebro-spinal pressure, but its success depends on operating without delay. Where symptoms of meningitis have been present for many days it will be too much to expect a high percentage of recoveries from this operation.

Heroic measures to establish suboccipital drainage do not appear to have been followed by the much-desired results in any single instance, and they are not therefore described in this article, though it is quite justifiable to tap the posterior horn of the lateral ventricle.

Lumbar puncture.—In acute otitis media where an intracranial complication is suspected, exploratory lumbar puncture is frequently necessary. Fluid is withdrawn for bacteriological, cytological and chemical examination. It is also important to ascertain whether the cerebro-spinal fluid is under excessive pressure or not.

When the cerebro-spinal fluid appears perfectly clear, only sufficient fluid should be withdrawn in the first instance for examination purposes, but where it is turbid and under pressure, it should be allowed to flow slowly until the pressure appears normal. Sometimes—especially in cerebellar abscess—the withdrawal of even a few cubic centimetres of cerebro-spinal fluid is followed by arrest of breathing. The surgeon must be prepared for this contingency, which is an indication for immediate exploration of the cerebellum while artificial respiration is maintained.

BRAIN ABSCESS (OTOGENIC)

The surgical principles guiding the treatment of abscess of the brain are the same as those which direct the treatment of abscesses in other parts of the body, namely, evacuation and drainage. The diffluent, soft, " jelly-like " properties of normal brain tissue render evacuation and after-drainage of the abscess-cavity peculiarly difficult. Moreover, there is very great liability to diffusion of the infection to vital regions ; this constitutes the essential danger of the disease.

The usual clinical signs for detecting the presence of an abscess are notably modified by the situation and the enclosure by bone. It is from circumstantial rather than from direct evidence that the surgeon infers an abscess in the brain. The time-honoured trio, headache, vomiting, and optic neuritis, associated with evidence of an original infective process, are to be regarded as very general guides to the existence of brain abscess.

This chapter considers brain abscess resulting from middle-ear disease ; it may take the form of (1) cerebellar abscess, or (2) temporo-sphenoidal abscess. (*See* also p. 1266.)

1. CEREBELLAR ABSCESS

The close proximity of the petrous part of the temporal bone to the anterior surface of the cerebellar hemisphere permits infective processes from the mastoid antrum, mastoid cells, and internal ear to reach the cerebellum by direct paths of infection. In the course of operations on the mastoid a track of infection may be found leading to an extradural abscess in the posterior cranial fossa, or even to a cerebellar abscess, when no obvious symptoms had been observed beforehand. (Fig. 631.) Approximately one-third of the cases of cerebellar abscess are preceded by infection of the lateral sinus and, when these complications co-exist, the signs and symptoms due to invasion of the sinus are likely to obscure those due to cerebellar abscess. (Fig. 632.) In one-third of the cases of cerebellar abscess from disease of the middle ear, destruction of the labyrinth occurs before the brain is invaded. The vertigo and vomiting caused by the labyrinth disease may have occurred weeks, months or years before the formation of the abscess in the brain. In the remaining one-third of the cases, cerebellar

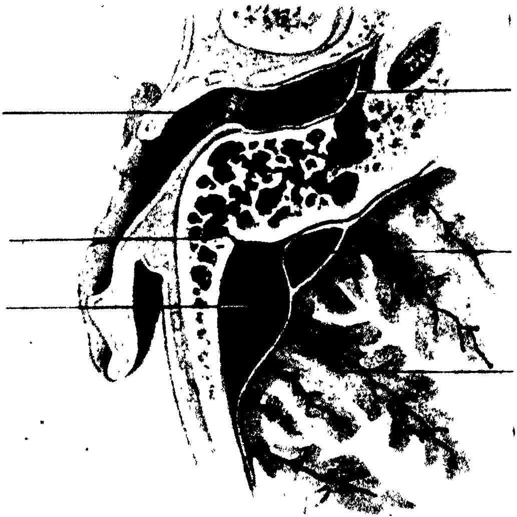

Fig. 631.—Extradural abscess : horizontal section of temporal bone through external auditory meatus and mastoid cells.

1, External auditory meatus ; 2, mastoid cells ; 3, extradural abscess ; 4, tympanum ; 5, sigmoid portion of lateral sinus ; 6, cerebellum.

abscess develops independently of lateral-sinus involvement (Fig. 633) or of labyrinth infection. The path of infection then leads from the antrum or adjacent cells into the posterior cranial fossa on the mesial or lateral side of the sigmoid sinus; not infrequently an extradural abscess forms first on the posterior wall of the petrous, below the superior petrosal sinus, and generally bounded by the sigmoid sinus on the outer side. Sometimes the whole sigmoid sinus is displaced from the sigmoid groove by the extradural abscess.

The development of cerebellar abscess is generally protracted, thus differing from labyrinthine invasions, the onset of which is always sudden. Exploration of the brain for cerebellar abscess must be justified by definite data. The diagnosis is made by careful consideration of the general clinical features and the results of certain special signs and tests. The history is often of great importance. When, in the course of middle-ear suppuration, severe headache develops, with rigidity of the cervical muscles in the suboccipital region, the surgeon must consider abscess of the cerebellum amongst other possible causes. There may be vomiting, staggering gait, and the general manifestations attributable to increased intracranial pressure. The surgeon must beware of attempting to lower this pressure by lumbar puncture alone. The neurological signs and symptoms associated with cerebellar inefficiency, viz. asynergia, hypermetria, and hypotonia, must be sought, though they seldom occur simultaneously. Reflex symptoms, such as hiccough and

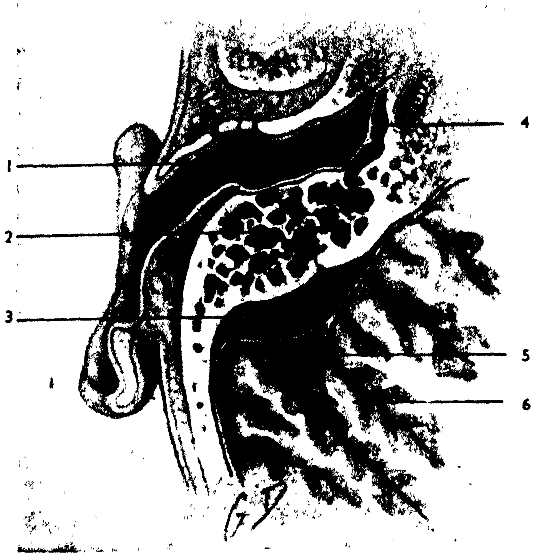

Fig. 632.—Extradural abscess, subtentorial (horizontal section).

1, External auditory meatus; 2, mastoid cells; 3, extradural abscess anterior to sigmoid sinus; 4, tympanum, 5, sigmoid sinus; 6, cerebellum.

yawning, are not infrequent in cerebellar abscess. Ocular nystagmus is generally present, while paralytic strabismus and œdema of the retina are also often, though not always, discovered. Giddiness is not such an essential feature of cerebellar disease as it was formerly thought to be, though it may be prominent ; for instance, it occurs repeatedly in temporary disturbances of an intact labyrinth, and also when the labyrinth is in process of dissolution, generally as the result of invasion from the middle ear (*see* p. 1310).

Cerebellar abscess occurs in acute as well as chronic otitis media. It is well to bear in mind the possibility that the infection of the middle ear may have resolved, so far as the tympanum is concerned, after the infection has already passed on through the dura mater into the great horizontal fissure of the cerebellum. Here in turn the track may again resolve as the infection proceeds, and finally the abscess may be found in the posterior part of the cerebellar fossa.

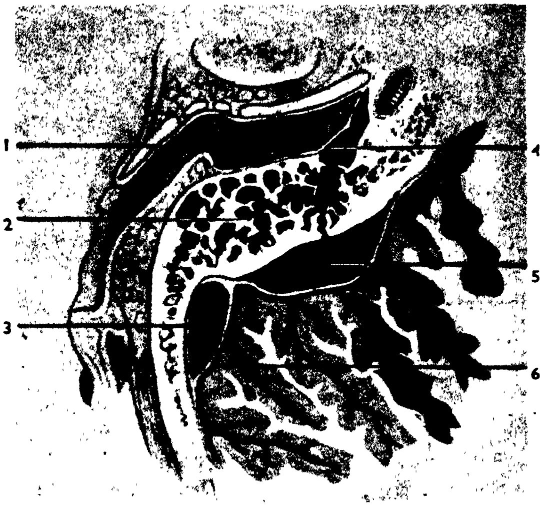

Fig. 633.—Extradural abscess, subtentorial (horizontal section).
1, External auditory meatus ; 2, mastoid cells ; 3, sigmoid sinus ; 4, tympanum ; 5, extradural abscess mesial to sigmoid sinus ; 6, cerebellum.

Symptomatic diagnosis of cerebellar abscess.—Deafness may be that of the ordinary middle-ear type, or it may be intense and absolute on the affected side. Acute otitis and deafness may have passed off by the time the patient develops signs of cerebellar abscess.

Discharge from the ear.—A trustworthy history of recent otitis media is very important. There is not necessarily any discharge, mastoid pain, tenderness, or swelling, or any other abnormally sensitive area, but sometimes the affected side is decidedly tender, especially in the suboccipital region.

Headache.—The headache is generally severe and referred to the frontal or occipital region. At first it may last only a few minutes at a time, but eventually becomes continuous. The patient may have had attacks of severe headache, and be free from pain at the moment of examination.

Vomiting.—Occasional vomiting is a common though not an essential symptom.

Pyrexia.—Although general teaching emphasizes the association of *subnormal* temperature with abscess of the brain, it should be borne in mind that abscess secondary to middle-ear disease is often accompanied by pyrexia. The temperature may be either a little above or a little below the normal. Every now and then there may be a sudden rise or a sudden occasional transient fall. A rigor is rare unless the sigmoid sinus is also involved.

Pulse-rate.—This is not necessarily slow ; it is often above normal ; it may be normal for days together, and there may be sudden isolated falls.

Head retraction.—Head retraction, or resistance to forward flexion, is almost invariably present, particularly in the later stages.

Kernig's sign is generally present. The patient will often prefer to lie at full length or even stand erect, to avoid a flexed forward position, as in sitting.

Rombergism, though often present, may be absent even when the abscess is large.

Nystagmus.—In the early and late stages there may be no nystagmus, but the diagnosis of cerebellar abscess would seldom be justified in the continuous absence of this important sign. The nystagmus is usually but not invariably similar to that met with in other hemispherical lesions of the cerebellum. " Spontaneous nystagmus was well marked on deviation of the eyes to the left when the head was erect (the patient had left-side cerebellar abscess), the rhythmic movement was concomitant and possessed considerable amplitude, so that the nystagmus elicited when the eyes were directed to the left was quite obvious. The period of movement of the eyeballs alternated regularly, so that each rapid jerk towards the side of deviation was succeeded by a slower movement in the opposite direction. On deviation of the visual axes to the right, with the head erect, no nystagmic movement was noticed at first, but on closer inspection a very fine rhythmic nystagmus was observable, the amplitude of movement being much less than that seen when the eyes were deviated towards the left ; the direction of movement on deviation to the right appeared to be purely horizontal with a distinctly alternating period, the rapid jerk being towards the side of deviation. In a day or two the nystagmus, on deviation to the right, became more easily recognized and the direction of movement distinctly oblique and slightly rotatory (torsional), with a rapid jerk towards the side of deviation."*

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* From the report of a case by the author in *Proc. Roy. Soc. Med.*, Otol. Sect. 1909, ii, 4.

Optic neuritis.—Œdema of the retina is valuable evidence of increased intracranial pressure, but the absence of optic neuritis does not negative the diagnosis of abscess of the cerebellum.

Special neurological tests for cerebellar abscess.—**Asynergia,** as described by Babinski, is characterized by a loss of the faculty of association of movements with a want of synchronization. Purposeful movements of the upper or lower extremities appear to be carried out rather slowly in comparison with those of the opposite limbs, and are not only exaggerated (hypermetria) but appear to be wanting in smoothness. In purposeful movement of the whole limb, individual joint movements appear detached and excessive.

Hypermetria.—The well-known finger-to-nose test is an example of asynergia when resulting in exaggerated movement (hypermetria on the homolateral side), and is frequently noticed in cerebellar abscess. The cerebellar patient will overshoot the mark on the affected side, whereas the healthy subject will carry out these movements correctly without difficulty with both arms.

Dysdiadokokinesia, or difficulty in making alternate movements—another special example of asynergia—may be observed ; for instance, when the patient rapidly alternates pronation and supination of the forearm (on the side of the lesion).

Hypotonia (homolateral muscular asthenia).—The patient may have a subjective sense of asthenia in the upper and lower extremities on the homolateral side without any definite paresis or paralysis. Homolateral hypotonia must not be confused with contralateral monoparesis, due to a cerebral lesion.

Cerebellar catalepsy is sometimes, though rarely, found. There may be prolonged immobilization of the limbs in certain positions of static equilibrium ; the phenomenon may be observed when the patient has become unconscious ; a raised arm will remain elevated until passively replaced to the patient's side.*

Staggering gait.—When attempting to walk along a straight line with the eyes open, the patient with cerebellar abscess may swerve away from the lesion ; especially is this likely if the labyrinth of the affected side has been previously destroyed by disease. The patient may be conscious of walking with a wide base, as if intoxicated, although he may have no subjective sensations of giddiness. In pointing at a given object within reach, eyes closed, the hand or the foot errs towards the side of the lesion.

Diagnostic lumbar puncture.—Lumbar puncture is performed in these cases to ascertain the appearance and state of the cerebro-spinal fluid, and to ascertain whether leptomeningitis has already set in. Not more than 2 or 3 c.c. should be withdrawn for pathological tests. When, in the course of an operation for middle-ear disease, there is reason to suspect some cerebellar complication, and the patient stops breathing, the surgeon must not abandon the operation, but should relieve the intracranial pressure as rapidly as possible, while his assistants are performing artificial respiration. Cases of complete recovery from cerebellar abscess have been reported from time to time, even though the patient ceased to breathe before the operation was commenced. In one such case operated on by me, artificial respiration was carried out for about three-quarters of an hour while an abscess of the cerebellum was opened. Although the patient remained comatose for four days he eventually recovered, and is still in robust health twenty years later.*

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* Proc. Roy. Soc. Med. (Otol. Sect.), 1923, xvi, 57.

Technique of the operation.—Stage 1. Mastoid operation.—Schwartze's operation (p. 1292) is the first step.

Two routes are now available for opening the cerebellar fossa: (1) the mesial; (2) the lateral, in relation to the sigmoid sinus. The commonest site for a cerebellar abscess is close to the anterior surface of the lateral lobe, about the level of the mastoid antrum—that is to say, below the plane of the superior border of the petrous.

Stage 2. Exposure of the dura mater of the posterior cranial fossa.—An incision of the scalp, 3 or 4 in. long, is made along the superior curved line. The pericranio-cervical muscles attached to the superior curved line and suboccipital region are detached with a periosteal separator, and the branches of the deep occipital artery and of neighbouring vessels are picked up with pressure forceps. Sometimes a mastoid accessory vein causes very troublesome bleeding, though it is controllable by pressure with gauze or Horsley's wax. A triangular area of bone is thus exposed, the antero-superior angle corresponding to the region of the mastoid antrum, the antero-inferior angle to the apex of the mastoid, while the posterior angle is formed at the termination of the incision along the superior curved line. In removing the bone, different methods are adopted. A broad gouge is preferable to the circular trephine. The gouge is laid on in a plane almost parallel with the surface of bone, so that long, broad, thin chips can be removed; the whole of the outer table is thus sliced away. Here and there the inner table will also be removed, exposing the dura mater. Small bone-forceps can then be inserted to enlarge such openings sufficiently to permit the introduction of the larger bone-forceps, with which the inner table can be more rapidly cut away. In a few minutes it is possible to expose an oval area, 5 or 6 cm. by 3 or 4 cm. in diameter, without injuring the dura mater.

The area of the dura mater exposed may appear normal for the most part, except where an extradural abscess is encountered. The colour and appearance of the membrane will be noted, and any granulations carefully investigated to ascertain if they surround a fistula leading into the cerebellar abscess. Such a fistula may be found, either on the mesial side of the sigmoid sinus or on its external side, or it may lead directly into or through the inner wall of a thrombosed sinus.

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* *Proc. Roy. Soc. Med.* (Otol. Sect.), 1923, xvi, 57.

Stage 3. Opening the dura mater.—When possible, it is desirable always to open a cerebellar abscess through the pathological route of infection, that is, generally through the anterior wall of the cerebellar fossa. But in cases where the tension in the posterior fossa is high, it may be better to expose the cerebellum through the postero-inferior wall of the cerebellar fossa external to the sigmoid sinus, especially when pulsations of the cerebellum cannot be seen or felt. The dura mater should be incised radially, to permit free herniation of the cerebellum before the abscess in the brain is opened. It is quite likely that, in the circumstances, the abscess will be found to be more accessible by this artificial route than by following the pathological route. The gravest risks of cerebellar abscess are caused by absence of localized meningeal adhesions at the site of drainage. Attempts have been made to induce adhesions to form by the application of, say, 10 per cent. iodine, in very small quantity, to the edges of the incised dura mater.

Drainage.—While it is difficult to dogmatize on such a subject as drainage of a brain abscess—for recovery after complete evacuation of the abscess by aspiration or otherwise sometimes ensues when no drain has been provided—rubber drainage-tubes are generally superior to gauze plugs, or to tubes of glass, silver or bone. Two or more rubber tubes, in parallel, have proved most successful: concentric metal tubes, on the tracheotomy principle, have yielded good results. The tubes should be sutured to deep fascial fixed tissue, *not* to the skin.

Dressings.—After partial closure of the wound by suture, the cavity may be lightly filled with gauze, lightly covered with outer dressings, wool, and bandage or cap.

After-treatment.—The treatment consists in daily dressings and attention to the drainage-tubes until the patient's condition and the state of the wound have improved sufficiently to allow complete closure by secondary suture—say about six weeks after the abscess has been opened and drained.

Results.—Recovery took place in rather more than 50 per cent. of cases of cerebellar abscess operated upon, and there seems to be no reason why these figures should not be improved if greater accuracy in diagnosis is achieved, so that fruitless exploration, as well as undue delay, may be avoided. Compared with successful operations for cerebral abscess, which may leave some permanent mental or other defect, recoveries from cerebellar abscess are usually much more complete, leaving no deficiency, mental or physical or cerebellar.

TEMPORO-SPHENOIDAL ABSCESS

When suppuration within the brain substance is due to otitis media, it begins by direct extension of the infective processes from the temporal bone, through the dura mater, into that part of the brain cortex lying directly over the seat of infection. (Fig. 634.)

In half the cases of temporo-sphenoidal abscess the outer surface of the dura mater is visibly diseased at the seat of infection, being hyperæmic, granular, and thickened, and often coated with a layer of pus or lymph, or else it is ulcerated, or sloughing, with a fistulous track leading directly through the dura into the temporo-sphenoidal lobe.

Even where the outer surface of the dura mater directly over the origin of infection appears to be normal, its inner surface generally becomes adherent to the pia-arachnoid membranes and to the brain cortex at the site of invasion. Moreover, as a rule the floor of the abscess in the temporo-sphenoidal lobe is only a few millimetres from these adhesions. (Fig. 635.)

Sometimes the presence and site of brain abscess may be revealed by erosions and destruction of the roof of the antrum and adjacent cells leading directly to the midcranial fossa seen in the course of a mastoid operation. The more chronic the disease of the ear, the greater the likelihood of cranial penetration. (Fig. 636.)

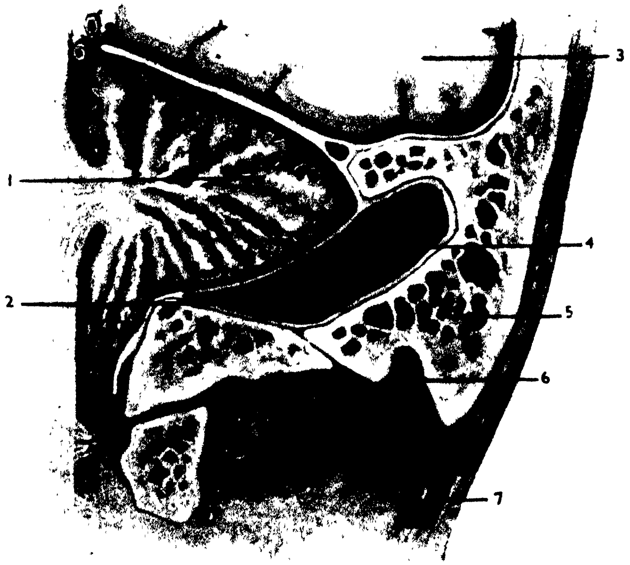

Fig. 634.—Coronal section of temporal bone through mastoid process, showing topography of mastoid cells to brain and sigmoid sinus.

1, Cerebellar hemisphere ; 2, entrance to jugular bulb ; 3, temporo-sphenoidal lobe ; 4, sigmoid sinus ; 5, mastoid cells ; 6, posterior belly of digastric ; 7, sterno-mastoid.

Suppuration in the substance of the temporo-sphenoidal lobe may progress in several different ways. For instance, on the one hand the infection may rapidly set up diffuse encephalitis around the abscess ; on the other, the inflammatory process may remain strictly localized, a dense capsule eventually forming in the walls of the abscess. So thick may the walls become, that the mass presents the appearance of a solid tumour until bisected. Owing to the increased density the thickly encapsuled abscess may migrate, perhaps under the influence of posture, from the seat of its origin and be found situated in the fronto-

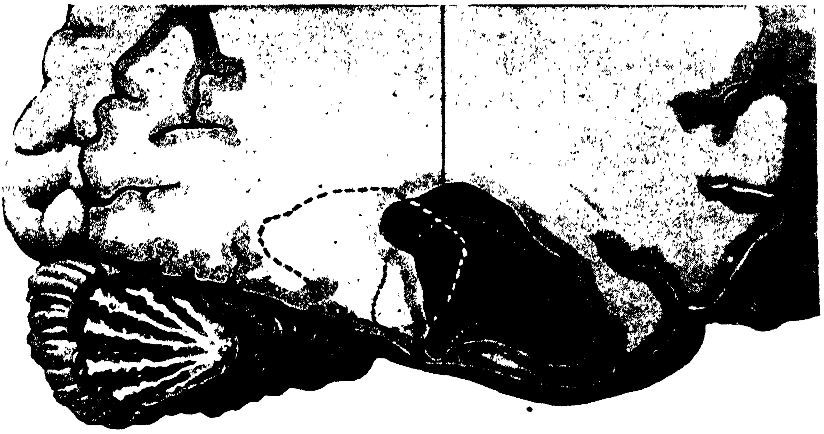

Fig. 635.—Temporo-sphenoidal abscess, vertical section, antero-posterior. Vertical line indicates mid-coronal plane. Dotted lines indicate the usual sites of abscesses.

parietal, parietal, or occipito-parietal region. This migration never occurs with thin-walled abscesses.

Sometimes an abscess with a thin membranous capsule will steadily enlarge at the expense of brain tissue without any surrounding extra-capsular infiltration or swelling. In such cases the abscess may destroy practically the whole of the temporo-sphenoidal lobe, extending back towards the occipital pole.

A patient presented the characteristic signs of a cerebral tumour involving the uncinate lobe, with defects of smell, for two years before it was discovered to be due to a thickly encapsulated bilobed hourglass-shaped abscess in the anterior and mesial part of the temporo-sphenoidal lobe.

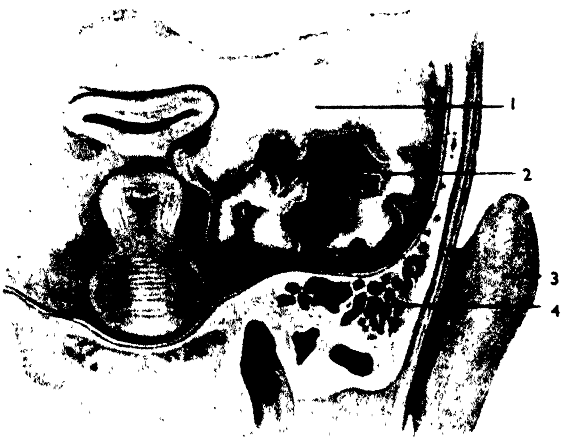

Fig. 636.—Coronal section of head, to show right-sided temporo-sphenoidal abscess due to middle-ear disease.

1, Temporo-sphenoidal lobe ; 2, abscess cavity ; 3, pinna ; 4, mastoid cells.

Though the classical symptoms of brain abscess are well known, they are sometimes absent, and the patient's fate is sealed before the diagnosis becomes clear, owing to the abscess suddenly bursting into the lateral ventricles, or penetrating the cortex of the brain and leaking into or flooding the intradural space. The picture is then that of fulminating meningitis.

The surgeon must approach the question whether there is an intracranial infection from middle-ear disease with the knowledge that the decision is of supreme importance and not merely of clinical interest. If he explores the brain simply because an abscess is suspected to be in process of formation, he will often fail to find one. Furthermore, there is reason to believe that premature explorations may cause an abscess to develop.

Naturally, a disease running such diverse courses will often present great difficulties in diagnosis.

Symptomatic diagnosis of temporo-sphenoidal abscess.—As a rule, the patient is under observation before the diagnosis of brain abscess can be definitely made. He is obviously ill, and has disease of the ear. The existence, or recent occurrence, of tympanic suppuration is more important than the apparent extent of the ear disease. The history of recent earache, deafness, tinnitus, with perhaps pyrexia, following sore throat or rhinitis, particularly in the course of influenza, pneumonia, or a specific fever, is of unquestionable importance.

Besides ear disease, there are headache, feelings of disturbed health, loss of energy, perhaps vomiting and pyrexia. Nothing more may be discovered for some time. The pyrexia may have ceased or recur occasionally. There may be isolated instances where the temperature is subnormal for a few hours. The pulse-rate may be normal or slightly raised, with an occasional and brief drop of 10 to 20 beats per minute.

Eventually the classical cerebral syndrome, headache, vomiting, and generally optic neuritis, points to increased intradural tension.

Headache.—This may be severe, persistent, and agonizing; the patient may become almost maniacal unless relieved. Sometimes the pain is localized to one side or is a radiating generalized fronto-occipital pain. In some cases there are more or less prolonged intermissions.

Vomiting is not always present or frequent. It is apt to occur on waking or moving.

Optic neuritis usually does not develop until late, compared with its earlier appearance in cerebellar abscess, perhaps because the latter, owing to its position, may more easily cause distension of the cerebral ventricles. Cushing drew attention to a degree of dilatation of the venules of the upper eyelid as being a fair index of the degree of stasis revealed by the ophthalmoscope.

Pulse and respiration are inclined to be slow when general intradural tension rises.

Stupor and **torpor** eventually develop.

A **convulsion** or a **rigor** occurs occasionally.

Before the onset of stupor or torpor the patient's mental alertness and activity have probably become affected. A want of accuracy in reasoning and judgment may be obvious to the patient himself; his memory becomes capricious, he lacks power of recognition, discrimination, and decision. These interferences with the intellectual faculties are even more noticeable to his friends, and can be demonstrated by testing his accuracy in reading, spelling, calculation, and especially by laying objects before him to name.

Word amnesia causing **pseudo-phasia** is of special importance in the localization of an abscess to the temporo-sphenoidal lobe of the left side in right-handed individuals (the reverse, of course, in left-handed persons). This inability to correlate ideas of objects with names of objects is discovered when a patient is shown numerous common articles such as a pencil, a pen, a penknife, a pair of scissors, a pin, or a bunch of keys, and is asked to name each in turn. A few may be correctly named but if there is marked hesitation or inaccuracy, this may be regarded as corroborative evidence of a left-side lesion of the temporo-sphenoidal lobe.

Contralateral hemiplegia.—When a brain abscess is not diagnosed until it has led to hemiplegia the prognosis is more grave. Convulsive twitchings of the limbs on the opposite side may precede paralysis.

Increase of the deep reflexes indicates involvement of the cortical radiation or of the internal capsule.

Successive (supranuclear) contralateral paralysis of the face, arm and leg would indicate extension of the encephalitis upwards, while rapid onset of paralysis of leg, arm, and then face point to extension in a mesial direction towards the internal capsule. Hemiplegia does not necessarily indicate that the abscess itself has reached the motor tract, which may be affected by the surrounding œdema or by pressure, and, therefore, may be temporary. Besides hemiplegia there is contralateral hemi-anæsthesia, which develops as the abscess extends laterally and backwards, resulting in a *loss of sensation of the position of the limbs.*

Ocular palsies.—Either or both sixth nerves may be affected, and the third nerve on the same side is sometimes involved, the pupil being dilated or fixed.

Homonymous contralateral hemianopia is sometimes observed, and is attributable to involvement of the lateral radiation fibres to the occipital lobes. The pupils react to light when the rays impinge even on the blind half of the retina alone. Cushing drew attention to the frequency with which slight degrees of contralateral anopia are overlooked, especially in the early stages when only the upper quadrant of the opposite visual field may be affected (quadrantic anopia).

Treatment.—In dealing with otitic cerebral abscess we may follow the teaching of Ballance, who says: " The surgeon has no commission to trephine the skull in various situations according to surface measurements which, on anatomical grounds, would lead him to the surface of the lobe of the brain in which he has suspected an abscess. In seeking an otitic brain abscess the complete mastoid operation should first be done, and all disease in the bone followed to its limits; this may conduct the surgeon directly to the abscess, but *if not* he will have made up his mind from the symptoms whether to explore the temporo-sphenoidal lobe or the cerebellum."

In carrying out the operation it is important (1) to open and drain the abscess without infecting the surrounding brain or intradural space. This can be accomplished if the track of the abscess be discovered through adhesions of the dura mater to the brain. Failing that, (2) the abscess with its walls should be removed intact without opening it. Cases in which the abscess track cannot be found will be considered later.

The operation for temporo-sphenoidal abscess.—General and local preparation.—This is the same as for any extension of the mastoid operation (p. 1308).

Instruments and equipment.—The same instruments can be used to open the cranium as those required to perform the mastoid operation, and should include craniotomy forceps. In addition, a ¾-in. trephine and a trocar and cannula may sometimes be required. Sargent's clamp forceps for the scalp are most useful to control hæmorrhage, especially if a horseshoe flap is made. A small silver teaspoon may be useful for encapsuled abscess.

Stage 1. Mastoid operation and removal of the tegmen.—To remove the tegmen thoroughly, so much of the squamous portion of the temporal bone is cut away with forceps as to make a wide and efficient opening into the cranium; an extension upwards of the scalp-incision for about 3 in. is generally sufficient if the parts are well retracted.

Stage 2. Inspection of the dura mater.—While the assistant keeps the cavity dry, the surgeon carefully looks for signs of external pachymeningitis. He may find a fistula which leads directly upwards into the temporo-sphenoidal lobe.

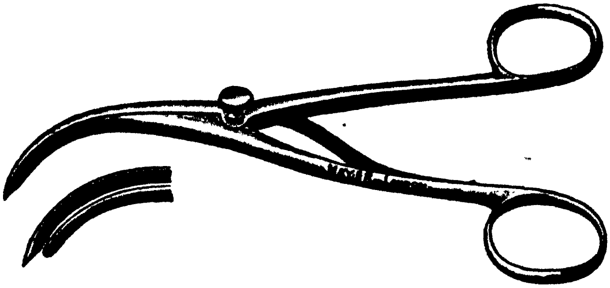

Fig. 637.—West's forceps for opening track of brain abscess.

Stage 3. Exploration of the brain.—(*a*) If a sinus or fistula is present, curved forceps such as those devised by West (Fig. 637) can be inserted, and the opening stretched sufficiently to allow pus to escape and enable the operator to introduce one or more rubber drainage-tubes into the abscess cavity.

(*b*) There may be signs of pachymeningitis in the region of the tegmen, without an actual sinus or fistula. A small incision must then be made across the centre of the visible area of diseased dura.

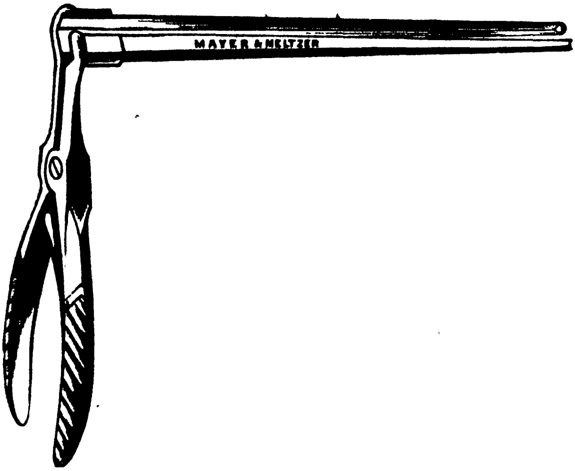

Fig. 638.—Horsley's brain seeker.

This incision is cautiously stretched open with the curved forceps. When this procedure fails to open an abscess, repeated punctures into the brain should not be made. It is permissible to stretch the dural opening with a seeker (Fig. 638) widely enough to permit the tip of the finger to be introduced. The finger will detect any seat of resistance and form a guide to the position of an abscess, or the operator may judge by means of a suitable probe (Cairns).

When a thickly encapsuled abscess is felt, it may be possible to enucleate it intact.

Stage 4. Enucleation of encapsuled abscess.—A small encapsuled abscess, when located near the dura mater, can be removed with a scoop or small teaspoon which Horsley used. When too large or located too far from the tegmen, it can be removed through the lateral cortex.

Absence of pachymeningitis externa.—In cases where the signs and symptoms of temporo-sphenoidal abscess are very evident, and yet no disease of the outer surface of the dura mater can be detected, the surgeon may have to expose the temporal lobe through a horseshoe incision of dura mater, as for tumour of the brain. If there is marked increased intracranial pressure, or cessation of pulsation of the brain, he should elevate the inferior part of the temporal lobe, and seek for evidence of pachymeningitis interna. If adhesions are visible from within, the brain substance may be incised below through the dura mater opposite the adhesions instead of through the exposed cortex.

Sometimes the abscess track cannot be found; that is, no pachymeningitis, either external or internal, can be discovered. Confirmation of the diagnosis of temporo-sphenoidal abscess is justified when pulsation is absent in the part of the brain exposed, or when the intracerebral tension is so high that the brain protrudes through the dural opening. In the latter event the cut edge of the dura can be incised radially, to allow the soft brain to herniate and " mushroom " and can be explored with curved forceps or even with the finger. Sometimes a surprisingly large abscess is found. The finger will serve as a guide for rubber drainage-tubes, which should be inserted and retained by sutures, to the pericranium, not to the skin.

In circumstances such as these, gauze well smeared with Bipp has proved useful. A coil of gauze is wound around the protruding brain, over which more layers of gauze are placed, and retained with a bandage. The *outer* dressings need not be disturbed for thirty-six to forty-eight hours; they should then be renewed, and the wound dressed daily. Generally, the less done to disturb the brain, the better the results.

If all goes well, the swollen brain recedes; sloughs are cast off, new granulations form, and in five or six weeks the wound may be ready for closure with sutures, after undercutting and freeing the skin.

CHAPTER XXIX

OPERATIONS ON THE EYE

By E. W. BREWERTON

OPERATIONS ON THE EXTRINSIC MUSCLES OF THE EYE

Anatomical considerations.—The four recti muscles arise from an oval fibrous ring, which is attached to the inner side of the optic foramen and, after bridging the sphenoidal fissure, is inserted into a prominent spine on the posterior border of the great wing of the sphenoid. The muscles therefore enclose the optic nerve at their origin and diverge from one another as they pass forward to reach the equator of the globe. Here their sheaths become continuous with the capsule of Tenon. The superior rectus is in relationship with the levator palpebræ, which lies on its upper surface for the first part of its course, and before it reaches the equator the superior rectus has the superior oblique below it. The inferior rectus also lies above the inferior oblique. After passing the equator the four recti muscles follow the curvature of the globe and become tendinous to their insertions in the sclerotic. The insertion of the internal rectus is 5 mm. from the edge of the cornea, that of the inferior rectus about 6 mm. and slightly to the inner side of the vertical meridian ; the insertion of the external rectus is about 7 mm. and of the superior rectus about 8 mm. from the cornea, slightly to the outer side of the vertical meridian.

The connective tissue of the anterior part of the orbit is of great importance. The sheaths of the muscles and the connective tissue between them, on reaching the equator of the globe, spread out forwards and backwards over its surface to form the capsule of Tenon. This fibrous sheath forms the anterior boundary to the orbital cone of fat. In front of the equator the capsule passes forwards under the conjunctiva and over the tendons of the recti to blend near the margin of the cornea with the episcleral and subconjunctival tissues, and into this blended mass the tendons send prolongations. Just behind the equator a sheet of fascia splits off from the sheaths of the muscles to become attached all round the bony ring of the orbit. The orbital fat can be regarded as a cup in which the globe moves. The lateral recti are inserted in the horizontal meridian of the eye and the movements resulting from the contraction of these muscles are simple. The superior and inferior recti are not inserted in the vertical meridian, and the upward movement of the eye is therefore the result of a combined movement of the superior rectus and the inferior oblique. Downward movement is a resultant of the combined action of the inferior rectus and the superior oblique.

SQUINT

Before an operation can be decided on there must be good vision in the squinting eye. This in many cases can only be obtained after covering the good eye for six days a week for some months. In children over five years of age, with a history of squinting for one or two years only, a certain amount of stereoscopic vision probably has been developed before the squint was noticed ; these cases can be helped considerably by orthoptic training, and operation can be avoided in a certain number.

A squint may be *concomitant,* i.e. there is the same degree of squint in all movements of the eyes. Or it may be *paralytic,* in which case, when the eyes are turned away from the direction of the action of the paralysed muscle there is no squint, but there is a marked squint when they are turned in the opposite direction.

Indications for operation.—An operation to correct the faulty position of a concomitant squinting eye should be undertaken in the following circumstances :

1. When the squint has been present for twelve months and shows no sign of improvement in spite of correcting glasses having been worn constantly during the period. The same remark applies to a congenital squint ; that is to say, it is advisable to straighten the eye when the child is twelve months old, unless there is a steady and continuous improvement. An early operation gives the child a chance of developing stereoscopic vision and of acquiring equal vision. If stereoscopic vision is developed sufficiently, it will also ensure that the eyes remain permanently straight.

2. When a squint has been present for three years an operation is not likely to cure, and should not be performed till the child has reached the age of 15 years or more. At this age local anæsthesia is sufficient, and the necessary alteration in position of the eye can be determined with exactitude. In these late cases there is no certain prognosis. The eye may return to its old position or may swing in the opposite direction.

3. Some patients with good stereoscopic vision keep the eyes straight with great difficulty owing to defective action of the muscle. An operation to advance the faulty muscle or to weaken its opponent is justified in the more severe cases only when the trouble has been proved to be permanent (heterophoria).

The squint which results from paralysis of an ocular muscle is not usually permanent ; when the muscle has recovered its function a certain amount of squint sometimes remains, for which advancement may be required.

If a paralytic squint shows no sign of recovery at the end of twelve months, advancement of the paralysed muscle and free tenotomy of its opponent is justified. The operation may relieve the patient of some of the diplopia which is always so troublesome, and enable him to hold his head in a more convenient position.

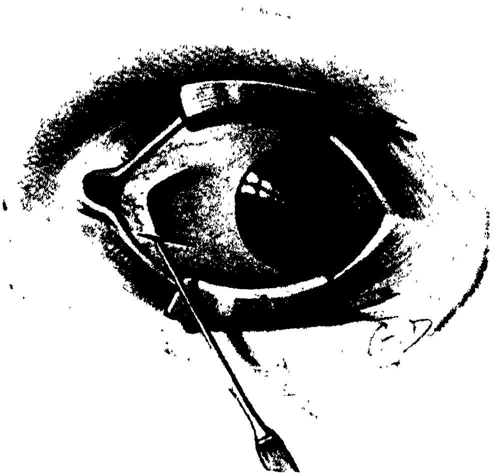

Fig. 639.—Subconjunctival tenotomy : first stage.

Choice of operation.—The operations performed for the relief of squint are:

1. Tenotomy.
2. Advancement.
3. Advancement with tenotomy.
4. Recession.

Free tenotomy should never be performed except when the opponent muscle is completely paralysed. Critchett's subconjunctival tenotomy does not disturb the fascial relations of the tendons or the check ligaments to any great extent, and need not be considered a free tenotomy.

A tenotomy which is less likely than any other to be too free is that of Bishop Harman, who lengthens the tendon by dividing it in three places.

Advancement is the operation to be chosen in almost every case. It is certain to produce a change of position of the eye up to 15°. If more than this is necessary it should be combined with Harman's partial tenotomy of the opponent, which would give another 10°. Any further rotation necessary must be obtained by treating the other eye in a similar manner.

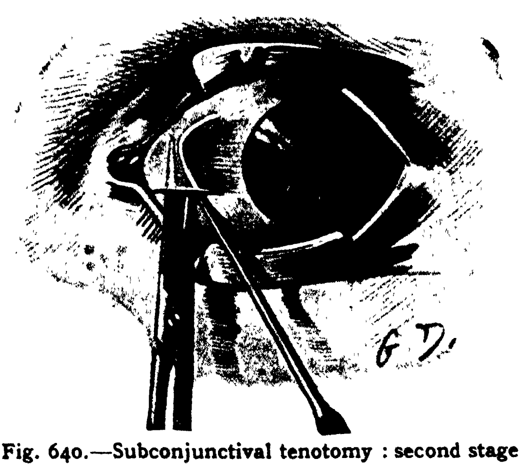

Fig. 640.—Subconjunctival tenotomy : second stage.

Tenotomy.—The conjunctiva and Tenon's capsule overlying the insertion of the muscle are picked up with forceps, and a vertical cut is made with scissors at the edge of the fold. A squint hook is passed into the opening and rotated under the tendon. The tendon is drawn out of the wound, one blade of the scissors is passed beneath it between the globe and the hook, and the tendon divided. The conjunctival wound should be closed by a suture.

Critchett's subconjunctival tenotomy.—A small fold of conjunctiva is divided with scissors at the lower edge of the insertion of the tendon, the subjacent Tenon's capsule is opened, and the squint hook passed beneath the tendon. (Fig. 639.) The scissors are now entered alongside the squint hook with one blade on each side of the tendon, which is divided between the hook and the globe. (Fig. 640.) A suture is required to close the conjunctival wound.

Bishop Harman's partial tenotomy or lengthening.—A conjunctival incision is made with strabismus scissors over the insertion of the muscle and at right angles to its tendon ; Tenon's capsule is opened to a similar extent. A squint hook is passed beneath the tendon, and is then replaced by one blade of Harman's director forceps. The forceps are locked and the tendon divided for two-thirds of its width on each side of the forceps and on the same side of the tendon, and then with the scalpel a final cut is made along the groove of the forceps, also for two-thirds of the width of the tendon but on its opposite side. (Fig. 641, E.) The conjunctival wound is closed with two sutures.

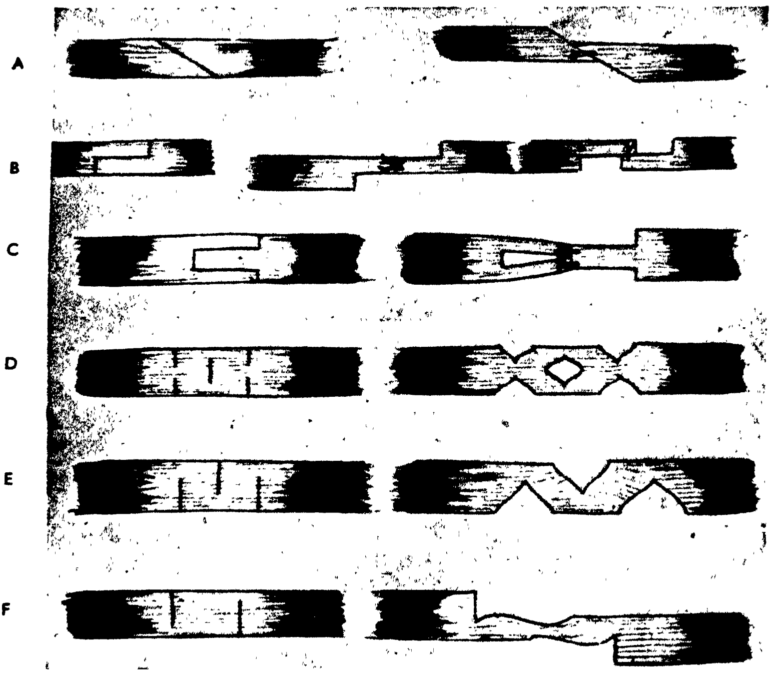

Fig. 641.—Various methods of lengthening tendon.

A, B, C, Stephenson's method. D, Verhoeff's operation. E, Harman's operation. F, Harman's operation to allow for vertical displacement.

Advancement.—A vertical incision is made through the conjunctiva and Tenon's capsule about 6 mm. from the limbus. A squint hook is passed beneath the tendon of the muscle, care being taken to include the lateral expansions of the tendon. One limb of a Prince's forceps

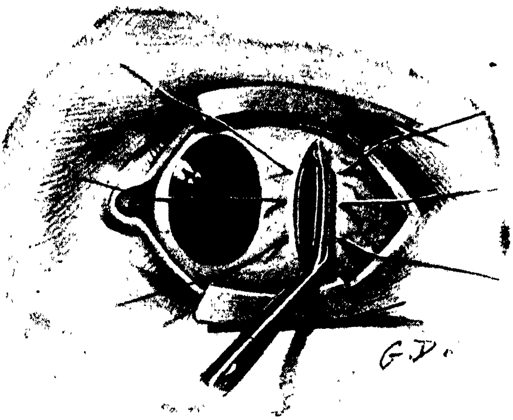

Fig. 642.—Advancement operation.

(preferably the toothed limb) is inserted alongside the hook, by holding the hook towards the insertion of the tendon ; the forceps can be clamped at some distance from the hook according to the amount of shortening required. The conjunctiva and Tenon's capsule overlying the tendon should be drawn forward and clamped in the forceps with the tendon. The hook is now withdrawn and the tendon divided on the anterior side of the forceps. Three sutures (they should be of silk, not too fine) will be required ; the central one should be passed like a mattress-suture, i.e. the needle is entered 3 or 4 mm. behind the Prince's forceps a little below the centre on the conjunctival surface, emerging between the tendon and the globe ; it is passed through the tendon insertion rather deeply so as to pick up some scleral fibres, and also just below the centre, and then through the conjunctiva near the limbus. The needle is now re-inserted through the conjunctiva and the tendon insertion just above the centre, and is made to re-appear behind the Prince's forceps 3 or 4 mm. from its site of entry. A single suture above and below this, and passed from behind forwards, completes the sutures. (Fig. 642.) The portion of tendon and conjunctiva held in the Prince's forceps is cut off as close to the posterior edge of the forceps as possible, care being taken to avoid the sutures. These are now tied as tightly as possible, the central one first. (Fig. 643.)

If this operation is combined with a partial tenotomy of the opponent muscle, the sutures should not be tied tightly until the tenotomy is completed, otherwise great difficulty will be found in inserting the hook beneath the tendon to be divided.

This operation would be more correctly described as a resection of the tendon. In a true advancement the needles are not passed through the

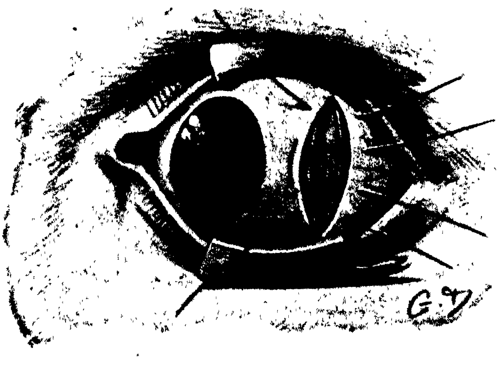

Fig. 643.—Advancement operation with central mattress-stitch.

stump of the tendon but through the superficial layers of the sclerotic half-way between the insertion of the tendon and the limbus. To perform this satisfactorily requires considerable experience and special needles. The results of true advancement, in my opinion, are in no way better than the resection method here described.

Recession.—An alternative operation to tenotomy, or to the lengthening of a muscle, is recession of the attachment. This is a more accurate operation and can be used either alone or in combination with advancement of the opposing muscle.

The new attachment of the muscle may be placed 5 mm. further back ; this will usually correct about 20° of squint when applied to the internal rectus and about 10° with the external rectus. The sclerotic behind the insertion of the recti muscles is much thinner than elsewhere, and care must be taken not to insert the point of the needle too deeply. As the superficial fibres of the sclera in this region are somewhat transparent, the point of the needle should be just visible throughout its course.

The instruments required are the same as for advancement.

A vertical section of the conjunctiva is made about 8 mm. in length much farther back than for advancement. An opening is made in Tenon's capsule above the upper edge of the muscle ; the hook is inserted, passed behind the muscle, and the capsule opened well below the muscle under the point of the hook. The capsule is now opened in a horizontal direction both above and below the muscle. The Prince's forceps are inserted and clamped close to the attachment of the tendon to the globe and the tendon is divided between the clamp and the globe. Three sutures are inserted as for advancement, both lips of the conjunctival wound being included. If chromicized catgut (10 day) is used, there will be no need to remove the sutures and much less reaction will follow the operation ; also the sutures may be inserted without including the conjunctiva, which is sutured separately.

OPERATIONS ON THE LIDS

Anatomy.—The skin of the lids is much thinner than that of any other part of the face ; it has little and very loose subcutaneous tissue and the hairs consist only of a fine down. Under the subcutaneous tissue is the connective tissue covering the orbicularis muscle. This is a well-developed circular muscle attached to the inner and outer margins of the orbit. In the upper lid beneath the orbicularis lies the tarsal plate ; this is a dense fibrous semicircular mass which forms the real skeleton of the lid. The posterior surface of the tarsus is lined by the adherent conjunctiva. In the lower lid the tarsal plate is poorly developed.

The muscles lifting the lid are the levator palpebræ, a band from the superior rectus joining the levator, and the occipito-frontalis. The levator rises from the apex of the orbit, close to the origin of the superior rectus, and is inserted chiefly into the upper margin of the tarsal plate ; a small part goes to the skin and another accessory portion to the upper fornix of the conjunctiva. The frontalis acts by raising the brows ; this draws up the skin of the lid and thus accentuates the action of the levator, but has very little effect when acting alone, unless some more direct connection can be made between the lid and the brow. The band from the superior rectus has even less action.

PTOSIS

Operations for the relief of ptosis are designed to make a better connection between the lid and the accessory muscles. The condition may be congenital or acquired. The *congenital* form, which is usually bilateral, is due to want of development of the levator palpebræ ; the *acquired* form—rarely bilateral—means a paralysis of that part of the third nerve which supplies the muscle.

When the condition is permanent, and severe enough to interfere with vision, surgical measures are necessary, except when diplopia appears on lifting the drooping lid.

Many methods are employed to deal with the trouble ; the most useful is that of forming a new connection between the lid and the occipito-frontalis.

In Motais's operation the superior rectus is divided longitudinally in three portions, the middle portion being inserted into the upper edge of the tarsus. This operation weakens the superior rectus considerably, and must only be done when the ptosis is bilateral and the superior recti muscles have normal power.

In congenital ptosis the superior rectus is usually weak from want of use, and often ill-developed.

The operation which can be recommended in almost all cases, both congenital and acquired, is that described by Hess.

Hess's operation.—A general anæsthetic is advisable. The eyebrow and the skin are painted with iodine, an incision is then made in the line of the eyebrow through its whole length ; the skin is dissected from the subjacent orbicularis muscle nearly down to the lid margin.

Three stout silk sutures are required, with a needle at each end. One needle is passed through the skin about the centre of the lid and close to the lid margin, passes up between the skin and orbicularis, and at the upper margin of the wound is entered deeply into the occipito-frontalis and then brought out through the skin about 15 mm. above the brow. The other needle enters 5 mm. to one side and follows a parallel course. The two remaining sutures are passed in a similar way. The free ends above the brow are drawn tightly until sufficient effect has been produced, and then each couple is tied in a bow over a piece of rubber tubing so that subsequent adjustment may be made if necessary. The wound in the brow is brought together with fine silk or, preferably, horsehair sutures. The deep sutures should be left in position for twelve to fourteen days.

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The result of this operation is to put a permanent fold or tuck in the skin of the lid and, by new formation of scar tissue, to bring the lid into a closer working union with the occipito-frontalis.

ENTROPION

Turning-in of the lid may be due to spasm of the orbicularis, limited to the lower lid, or to scar tissue beneath the lid, more common in the upper lid as a result of trachoma. Spasmodic entropion sometimes follows operations on the globe, and may then be due to bandaging. The bandage should be discarded, and the lid held in its normal position with plaster. Complete recovery usually results.

Operative procedure is necessary in most other cases of spasmodic entropion of the lower lid. Local anæsthesia is usually sufficient. A solution of 5 per cent. novocain with a trace of adrenalin is injected subcutaneously. An oval piece of skin about 30 mm. in length and 6 mm. in width is picked up with the special entropion forceps as close to the lashes as possible, and removed with scissors. The edges of the wound are brought together with horsehair sutures, and the wound painted with collodion. No dressing is applied.

Alcohol injection for spasmodic entropion.—Another method is to paralyse a portion of the orbicularis by injection of alcohol. This must be preceded five minutes earlier by the injection of 20 minims of 4 per cent. novocain. An equal quantity of 80 per cent. alcohol is then injected into the muscle about 10 mm. from the lid margin. The needle is entered below the outer canthus and into the muscle and passed to about the junction of the inner and middle third of the lid, and the alcohol is injected slowly as it is withdrawn. There may be considerable pain, which can be relieved by fomentations.

CICATRICIAL ENTROPION

The commonest cause of this form of entropion is neglected trachoma, which causes scar-tissue formation in the subconjunctival tissue of the upper lid. As this contracts, the tarsal plate acquires a curve of shorter radius; hence the lashes turn downwards and may touch the cornea.

There are many methods of dealing with this condition:

1. The lashes with their roots may be dissected out.
2. The lash-bearing area may be transplanted to a higher level, and the raw surface filled in with skin or mucous membrane.
3. The shape of the lid may be changed so that the lashes no longer point downwards.

It is not advisable to excise the whole lash-bearing area, but when a few lashes are badly placed they may be excised or their roots destroyed by electrolysis. When the whole row of lashes is affected, the lash-bearing area may be transplanted to a higher level.

In **Arlt's operation** an incision is made in the grey line of the lid throughout its whole length, and about 5 mm. in depth. A second incision is made in the skin of the lid 5 mm. above the lashes, and of equal length to the first incision, and meeting it in the depth of the wound. A bridge of tissue is thus formed, containing the lashes and their roots. A curved incision is made, meeting the extremities of the second incision, and about 5 mm. distant at the centre. A semilunar area of skin is thus marked out and excised. The bridge containing the lashes is stitched to the upper border of the raw semilunar area. A rather large raw area is left between the lashes and lid border, which in time will become covered by epithelium.

In **Spencer Watson's operation** the same incisions are made as in the previous operation, but the semilunar piece of skin, instead of being excised, is made to change places with the bridge containing the lashes. This is an improvement on Arlt's operation, but trouble usually follows from the downy hairs which grow from the transplanted skin and irritate the cornea.

Van Millingen's operation.—The insertion of mucous membrane instead of skin at the lid margin, first advocated by van Millingen, is a great advance. No incision is made in the skin of the lid, but the lid in the grey line is split and mucous membrane inserted into the groove. A general anæsthetic may be necessary. The lid is held firmly in a Snellen's clamp and an incision is made in the grey line of the lid throughout its whole length, and at least 3 mm. in depth. All the hair-bulbs should lie in the anterior segment. It is advisable to examine the posterior segment for any misplaced lashes: if found, they must be dissected out. The incision must not tail off at either end; it should be of equal depth throughout. The clamp should now be removed and placed on the lower lip, and two parallel incisions made in the mucous membrane about the same length as the wound in the lid, and 5 mm. apart. The two incisions are joined by a transverse cut at each end, and the parallelogram dissected off with scissors and forceps.

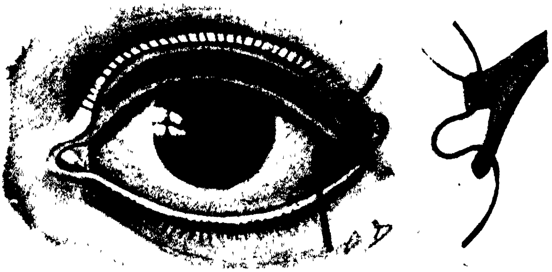

Fig. 644.—Van Millingen's operation, modified by Mutermilch.

Mutermilch keeps the mucous membrane in position by passing a suture through each lip of the lid wound and leaving the intermediate part as a loop (Fig. 644); he passes four of these, and then places the mucous membrane in position and draws the sutures tight. These are not tied, but are fixed by strapping or collodion to the brow and temple.

Story uses a different method of fixing the mucous membrane in position. He takes a curved needle and a fine suture, ties a knot at the end, and passes the needle through the extremity of the mucous membrane, entering it on the superficial surface, and the thread is drawn through up to the knot; a similar suture is passed at the other end. (Fig. 645.) One of the needles is now made to enter the end of the wound, and brought out through the edge of the lid beyond the incision. After passing the other needle at the opposite end of the incision the surgeon draws the sutures tight, and the mucous membrane is thus held in position. The ends of the sutures are fastened with strapping to the brow. Two or three fine sutures will be necessary to keep the central part of the mucous membrane in position. These may be passed in a similar manner and brought out just above the lashes.

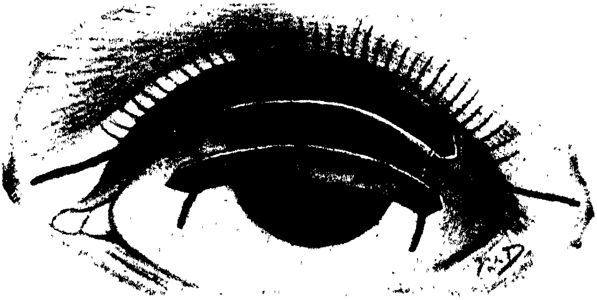

Fig. 645.—Story's operation.

Changing the shape of the eyelid.—The lid may be attacked from the skin surface or from the conjunctival surface. The disadvantage of the latter is the opening up of the cellular tissues of the lid to septic organisms, but as a matter of fact it is rare for any serious trouble to arise from this cause so long as no active inflammation of the conjunctiva is present.

From the skin surface: Snellen's operation.—An incision is made about 6 mm. above the lid margin in the whole length of the lid, the orbicularis muscle-fibres are divided and the anterior surface of the tarsal plate exposed. Two parallel incisions about 2 mm. apart are made in the tarsal plate throughout its whole length; these incisions slope towards each other, and so a wedge-shaped piece of tarsus is removed. Care must be taken not to perforate the conjunctiva, which is adherent to the posterior surface of the tarsus. Sutures are now passed. The needle enters the skin just above the wound and picks up the anterior layers of the tarsus ; it then passes through the lower segment superficial to the tarsal plate and appears at the lid margin in the grey line. One central and two lateral sutures are passed and, when tied tightly, should replace the lid margin in a good position. (Fig. 646.)

From the conjunctival surface : Williams's operation.—After everting the upper lid, an incision is made through the conjunctiva and tarsus parallel with and about 4 mm. from the lid margin. Three or four sutures are passed and tied over a roll of plaster (*see* Fig. 646) so as to evert the lid margin. An over-correction is required to allow for subsequent contraction.

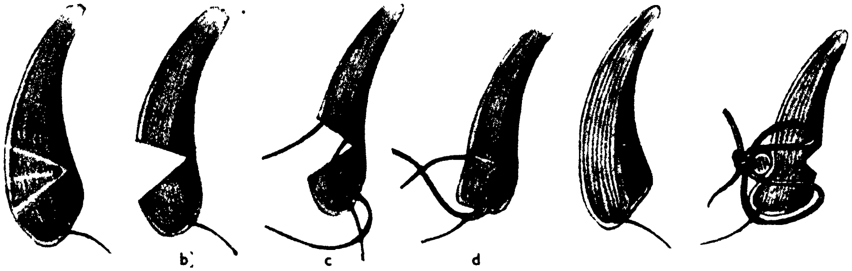

Fig. 646.—a, b, c, d, Snellen's operation ; e, f, Williams's operation.

Ectropion

Eversion of the lid, when due to cicatricial contraction of the skin, may affect either the upper or the lower lid ; the more common form is due to want of tone in the orbicularis muscle, and then is limited to the lower lid.

The orbicularis is supplied by the 7th cranial nerve, and when this nerve is paralysed much trouble results from inability to close the eye and from epiphora. The latter is due to the lower lid falling away from the eye, displacing the punctum, and leaving a space in which tears collect. No operative procedure is indicated if there is any probability of spontaneous recovery, unless the cornea is causing trouble from the exposure. In this event it may be necessary to reduce the width of the palpebral fissure—outer canthorrhaphy ; or even to sew the central portions of the lids together—median tarsorrhaphy.

Old people who suffer from blepharitis often have their lid trouble aggravated by ectropion of the lower lid. In these cases the exposed conjunctiva becomes much thickened and inflamed, and surgical interference is usually necessary.

In both the paralytic and the senile form of ectropion, when the condition has been present for many months, the lid is found to be elongated, and most of the operations have been devised to shorten the lid. If the lid is reduced to its proper length the eversion will disappear, and the thickening and inflammation in the senile form will also disappear in time.

In slight cases of ectropion Snellen's sutures may be sufficient. Two stout silk threads with two curved needles are needed. One is passed through the most prominent part of the exposed conjunctiva entering about 3 mm. to the inner side of the middle line and emerging at the lower edge of the orbit; its fellow enters about 6 mm. farther inwards, and the second suture is passed to the outer side of the middle line. These sutures are tied over a piece of rubber tubing and the lid thus rolled inwards. They are withdrawn at the end of eight days. When the lid is definitely lengthened, some operation for shortening must be performed.

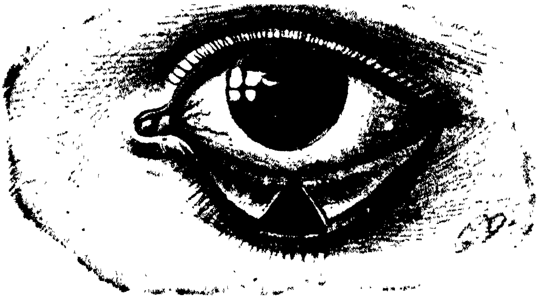
Fig. 647.—Kuhnt's operation.

Kuhnt's operation.—Local anæsthesia is usually sufficient. Before clamping the lid care must be taken to estimate the amount of shortening required. Two incisions are made with a small scalpel through the conjunctiva and tarsal plate to form a triangle with the base at the margin of the lid. An incision is now made in the grey line of the lid and this triangle removed. (Fig. 647.) Sutures are passed through the skin surface, and the conjunctiva accurately brought together; special care must be taken at the margin. As no skin has been removed, the immediate result is an ugly puckering of the skin, which is not permanent. In order to deal with this the following operation has been devised.

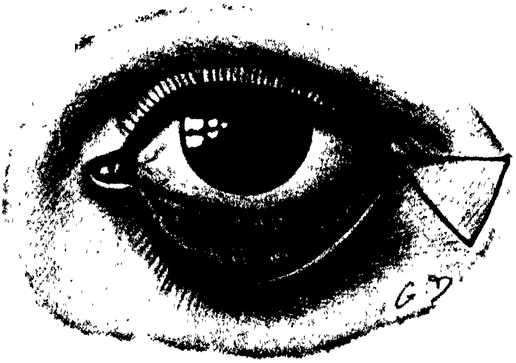
Fig. 648.—Dimmer's operation : first stage.

Dimmer's operation.—An incision is made with a small scalpel in the skin at the outer canthus for 6–10 mm., according to the amount of shortening required. (Fig. 648.) The direction should be slightly upwards. Two further incisions are made from either end of the first, which meet below to form an equilateral triangle. The skin is removed. The outer two-thirds of the lid is split in the grey line and a triangular piece of conjunctiva and tarsal cartilage excised in the middle third as in Kuhnt's operation, and equal in size to the excised piece of skin. (Fig. 649.) The margin of the lid at the outer canthus, with the hair-follicles, is excised for a distance equal to one side of the triangle. The lid is now drawn outwards to the outer angle of the triangle and sutured in its new position. (Fig. 650.) Finally, deep sutures must be passed through the skin of the lid in the middle line, as in Kuhnt's operation. (Fig. 651.)

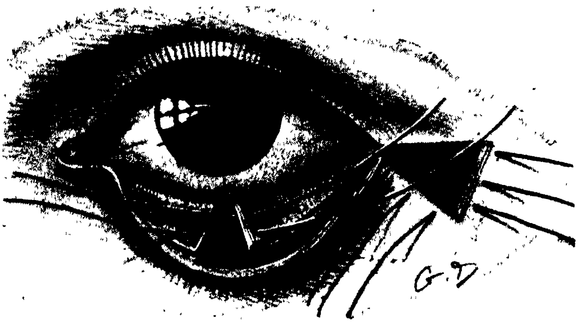

Fig. 649.—Dimmer's operation : second stage.

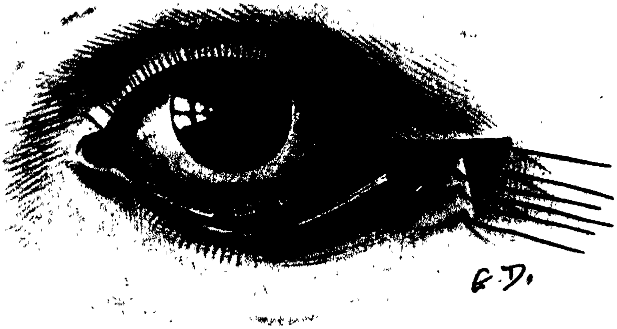

Fig. 650.—Dimmer's operation : third stage

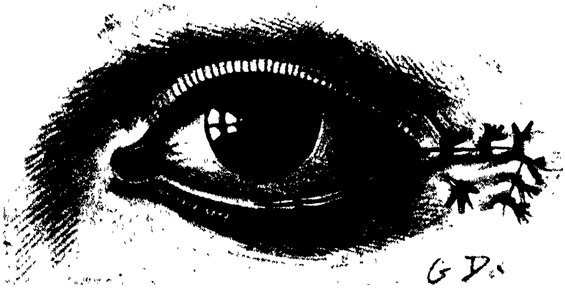

Fig. 651.—Dimmer's operation : fourth stage.

The above operations are somewhat complicated. For many years I have used a much simpler operation, as follows :

To shorten the lower lid.—Local anæsthesia is usually sufficient. The lid must be pinched up to decide how much it will be necessary to remove. It is then placed in a Snellen's clamp, one blade of a pair of straight scissors is passed between the clamp plate and the lid, and a cut made about 10 mm. through all the tissues of the lid to form one side of the triangle which is to be removed ; the second cut meets the first at the apex of the triangle, and the wedge-shaped piece of lid is seized with forceps and freed, if necessary, by further cuts with the scissors. The sutures must be passed carefully while the lid is still kept in the clamp ; they are passed deeply through the skin and orbicularis and tarsus, but not through the conjunctiva. One must be passed in the white line at the lid margin to ensure the correct line of the lid. None is tied until the clamp is removed.

CICATRICIAL ECTROPION*

In severe forms of cicatricial ectropion, particularly after burns, it may be found that the skin of the upper lid has been almost completely destroyed, and that what remains of the lid margin is in contact with the eyebrow. The lid is everted, and the eye in danger from exposure.

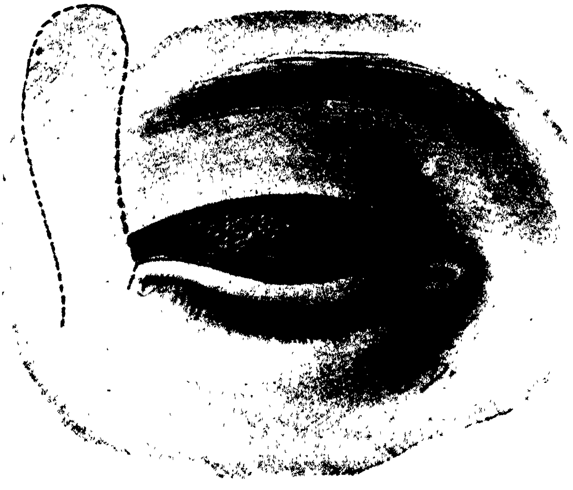

Fig. 652.—Fricke's operation : first stage.

A new upper lid must be devised by means of a pedunculated flap from the temple. Fricke was the first to devise an operation for such cases.

Fricke's operation.—A general anæsthetic is advisable. A horizontal incision is made in the scar, and the margin of the lid brought down to its proper position ; all scar tissue is excised. A piece of skin must now be marked out in the temple, about one-fourth larger than the raw surface to be covered; it is contained between two incisions which form an ellipse above. (Fig. 652.) The outer incision extends downwards below and about 12 mm. to the outer side of the outer canthus; the inner incision is continued to the outer edge of the raw surface. The skin-flap is dissected up from the subcutaneous tissue and, when sufficiently free, is rotated on its pedicle almost at right angles and applied to the raw surface to form the new lid, where it is sutured in position. (Fig. 653.) The edges of the temporal wound are now brought together.

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* *See also* pp. 1071–1073.—ED.

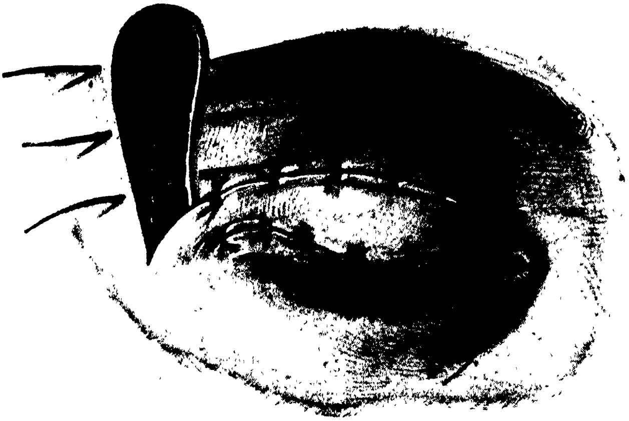


Fig. 653.—Fricke's operation: second stage.

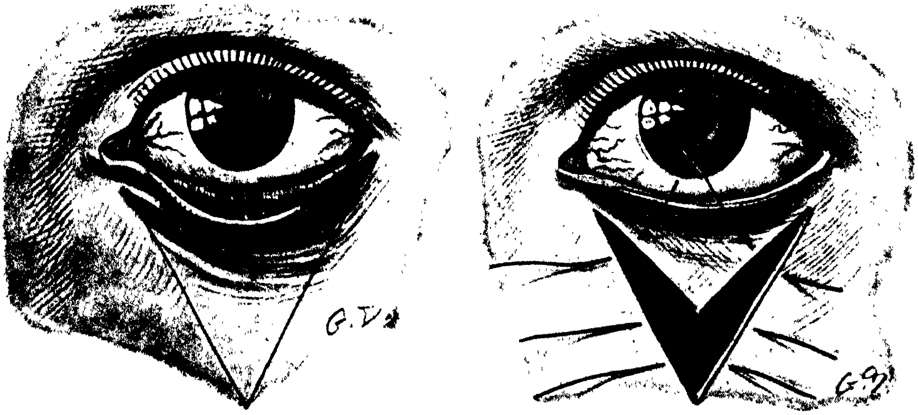


Fig. 654.—Wharton Jones's operation: first and second stages.

The dragging downwards of the lower lid by scar tissue may be relieved by **Wharton Jones's V-Y operation.** Two incisions are made from just below the inner and outer canthi, converging to meet 25 mm. below the lid. (Fig. 654.) As much scar tissue as possible should be removed, and the skin of the lower lid freed from the subcutaneous tissue until the lid can be replaced in position. This will leave a raw surface below the lid, and, if sutures are passed to bring the edges of the wound together, the V is changed into a Y and the lid supported in its proper position. (Fig. 655.)

TARSORRHAPHY AND CANTHORRHAPHY

The operation for joining the lid margins together is called tarsorrhaphy. When the union is at the inner or outer canthus it is called inner or outer canthorrhaphy, and as this union will be permanent the whole thickness of the lid margin is involved. The union of the middle portion of the lids is usually temporary and therefore only the posterior part of the lid margins is dealt with.

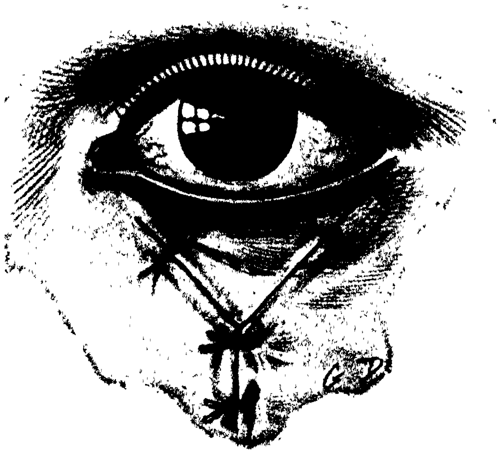


Fig. 655.—Wharton Jones's operation: third stage.

In neuro-paralytic keratitis and also in lagophthalmos, if the paralysis is expected to be permanent, a median temporary tarsorrhaphy combined with a permanent external canthorrhaphy may enable the surgeon safely to divide the median union at the end of a few months.

As a congenital defect the palpebral fissure is occasionally very much too large for the eye. In such cases an external canthorrhaphy will relieve the defect.

Several operations have been devised for this condition : in most of them the upper and lower lids are split horizontally for a short distance at the outer canthus, and the skin-wounds containing the lashes brought together. This leaves a disfiguring line of lashes beyond the new external canthus. A better result can be obtained by removing the whole of the lid margins for the required distance, and then bringing the raw surfaces together.

This operation is also useful when an artificial eye (although made correctly) is too small for the socket.

A special clamp for the outer canthus, which greatly facilitates the operation, has been designed by Bishop Harman. This clamp can be kept in position until all sutures are inserted ; they are tied together after its removal.

OPERATIONS ON THE LACRYMAL APPARATUS

The most frequent of these operations is the removal of the lacrymal sac.

Surgical Anatomy.—The sac lies in a groove formed by the lacrymal bone and the superior nasal process of the superior maxilla ; it is about 12 mm. in length and 5 mm. in width ; the lower end opens directly into the nasal duct. The upper part or dome lies behind the internal palpebral ligament, and extends for about 3 mm. above it. It is separated from the bony wall of the groove by periosteum and a loose areolar tissue containing a plexus of small veins. The angular artery and vein lie on the nasal side of the sac on a more superficial plane.

Chronic inflammation of the lining membrane of the lacrymal sac is usually due to obstruction in the nasal duct, which may be a sequela of chronic rhinitis. The sac is distended with mucus, which sooner or later becomes infected, causing a muco-purulent dacryo-cystitis. If the case is of recent origin, a cure may be effected by washing out the sac through the lower canaliculus every three days ; if no improvement results, an attempt must be made to pass a probe down the nasal duct ; and if this is unsuccessful, removal of the sac is necessary.

EPIPHORA

Extirpation of the lacrymal sac.—A general anæsthetic is advisable, but local anæsthesia often suffices. The incision, which must be about 30 mm. in length, should begin below at the inner and lower edge of the orbit, and extend upwards along the ascending process of the superior maxilla to a point about 10 mm. above the internal palpebral ligament. The superficial fascia is divided, and beneath this will be found, in the lower part of the wound, the muscle-fibres of the orbicularis, and in the upper part the horizontal fibres of the ligament ; this is a useful landmark, as the sac lies just below. At this stage small Axenfeldt retractors are inserted. The internal palpebral ligament is now divided, and the sac at once comes into view ; it can be recognized by its bluish colour. The dome of the sac must be freed by the scissors, and drawn downwards after its attachments on the ocular side of the wound, including the canaliculi, have been freed ; on the nasal side it will be found to lie loosely in its bony groove. Finally, it is drawn upwards, and the lower end divided as close to the nasal duct as possible. The depths of the wound must be examined to see that no part of the sac has been left behind, and the upper end of the nasal duct scraped with a small sharp spoon. The retractors are now removed, a deep suture is passed through the divided ligament, and the wound closed by horsehair sutures. Pressure must be maintained on the wound for at least three days by means of a small ball of gauze and a pad and bandage to keep the skin and deep tissues in close contact.

Alternative operations.—Instead of removing the sac, an attempt may be made to obtain direct communication between the sac and the nose. Toti resects a piece of bone from the lacrymal fossa, and then connects an opening in the sac with a similar opening in the nasal mucous membrane. West, working in the nose, removes a piece of bone from the outer wall of the nose just below and in front of the middle turbinate ; he then pushes the lacrymal sac into the opening by means of a lacrymal probe passed along the upper canaliculus, and excises as much of the sac as possible. This operation is described in the next article (p. 1891).

Operation for malposed punctum.—The above operations are for the relief of epiphora due to an inflamed lacrymal sac. But in many cases epiphora is due to a malposition of the lower punctum. This should lie with its inner edge in contact with the bulbar conjunctiva ; if the lower lid is thickened, or sags away from the eye, the punctum no longer lies in contact and cannot act as it should. The simple operation of slitting the canaliculus and removing the inner wall will relieve the symptoms, if the nasal duct is patent. To determine this the tear passage should be washed out with normal saline by means of a lacrymal syringe. If the fluid passes into the nose the passages can be considered to be normal, and the punctum attended to.

Two or three drops of 4 per cent. cocaine solution will make the operation practically painless. The punctum must be dilated with a dilator to allow room for the entrance of the knife ; the best knife for the purpose is Bowman's canaliculus-knife. With the lower lid drawn outwards, the knife is entered vertically with the edge towards the nose, and then inserted horizontally into the canaliculus for about 5 mm. ; it is now raised, with the cutting edge upwards, and withdrawn with a cutting movement so as to slit the canaliculus for about 3 or 4 mm. only. It is rarely necessary to make a longer cut than this. Two vertical cuts are made with sharp-pointed scissors, about 3 mm. apart in the inner wall, the outermost cutting through the inner wall of the punctum. At this stage it is a good plan to pass a small lacrymal probe to see that the cuts reach the canaliculus. This small quadrilateral piece of tissue is then seized with fine forceps and excised.

The epiphora due to dacryo-cystitis is not always relieved by removal of the lacrymal sac, although in most cases patients complain merely of the eye watering when exposed to cold winds. Pooley believes that such cases are due to the presence of inflamed canaliculi, and states that if these be removed the trouble will be cured. He passes a small probe along the canaliculus and dissects out the sleeve of mucous membrane with the probe in position. In rare cases it may be necessary to remove the lacrymal gland. There are two portions of this gland, the orbital or main gland, which lies in a depression in the roof of the orbit, and the palpebral portion, which lies beneath the conjunctiva. It is advisable to deal with the palpebral part first, and to wait for some weeks before removing the main gland. In removing the palpebral part, many of the ducts leading from the orbital portion are severed, and as a result the rest of the gland often atrophies.

Removal of the palpebral part of the lacrymal gland.—Local anæsthesia usually suffices. The upper lid is everted and the conjunctiva to the outer side of the fornix is seized with forceps and drawn downwards. An incision is made through the conjunctiva above the forceps, about 10 mm. in length. A sharp hook is passed into the opening, and the gland dragged down into the wound. It is freed from its attachments by means of the scissors, and as much of it as possible removed. The conjunctival wound should be sutured after hæmorrhage has been controlled.

Removal of the orbital part of the lacrymal gland.—A general anæsthetic is advisable. The incision, about 30 mm. in length, is made along the margin of the outer third of the upper orbital margin ; it divides the skin and orbicularis, and exposes the orbital fascia, which is attached to the periosteum at the orbital margin. This fascia is divided close to the orbital margin, when the anterior edge of the gland can be felt just below the bone ; it is seized with forceps and, after its attachments have been freed by means of the scissors, is drawn into the wound. The lacrymal artery enters its posterior edge, and should be ligatured, otherwise much orbital hæmorrhage and proptosis will result. After removal of the gland the skin is sutured, and firm pressure applied. (*See also* Operations on the Nose and Pharynx, p. 1390.)

OPERATIONS ON THE CONJUNCTIVA AND CORNEA

Pterygium is an overgrowth of conjunctiva on the nasal side which creeps over the corneal margin. If neglected it may invade the pupillary area and interfere with vision. It is usually progressive and therefore should be removed.

The removal of a pterygium is not difficult, but some care must be exercised to leave no part of it on the cornea and to bring healthy conjunctiva from above and below to cover the wound.

The head of the pterygium should be seized with forceps and dissected from the cornea with a sharp knife. Whilst still holding the head, the growth can be freed from the globe backwards for about 10 mm. with scissors and then removed. The edges of the conjunctiva are brought together with two or three fine silk sutures.

Peritomy.—This operation, which has been used for over half a century, is still very valuable in suitable cases, particularly when the cornea is covered with superficial vessels from recurrent inflammation. If the vessels are limited to one part of the cornea the operation is limited to this area. Local anæsthesia is usually sufficient. The incision, which is made with strabismus scissors, resembles the first stage of excision of the eye but, instead of dividing the conjunctiva as close to the cornea as possible, the line of incision should be about 3 mm. from the corneal limbus. When the incision is completed, the 3 mm. band of conjunctiva is removed and all subjacent vessels divided.

Trachoma.—Severe cases often require some surgical interference. The more usual operation in this country is to express the granulations by Knapp's roller forceps. This requires a general anæsthetic. The lid is everted, one blade of the roller forceps is pushed into the fornix as far as possible, the other blade resting on the conjunctival surface of the tarsus near the lid margin. The forceps are then compressed tightly and drawn down; as the rollers revolve the granules are crushed and their contents squeezed out. This manœuvre is repeated till all parts of the affected area have been treated. The surgeons and assistants must wear protective goggles as the infective material may be expressed with considerable force and may splutter about.

Conjunctival flaps.—These are of the greatest value when dealing with jagged wounds of the cornea. They produce rapid healing and thus help to prevent late infection. The flaps may be cut in various ways :—(1) with a broad pedicle ; (2) as a bridge ; and (3) as a hood, either partial or complete. The partial hood flap is the most usual. The conjunctiva is separated from the cornea at the limbus near the corneal wound, and freed from the subjacent tissues by dissection. In order to bring it well over the wound, it may have to be separated for half the circumference of the cornea. When sufficiently free to cover the wound easily, it is held in position by two sutures at the limbus.

A bridge flap is sometimes used in extraction of cataract to promote rapid healing in a restless patient, or when a septic conjunctival sac cannot be made sterile. Instead of cutting the usual small pendunculated flap, the knife cuts the conjunctiva upwards for 10 or 12 mm. and is then withdrawn, leaving a bridge of conjunctiva with parallel sides. The subsequent extraction of the cataract is rather more difficult, otherwise this would be the routine method.

Conical cornea.—Operations for conical cornea are not so frequent as formerly owing to the invention of the Zeiss contact glass. These glasses are very expensive, and in hospital patients an operation may be necessary in severe cases. There are two methods of operating—the electric cautery and the knife.

The cautery.—Critchett's method consisted of burning two concentric circles around the apex of the cone and then burning the centre as deeply as possible, short of perforation. Later an optical iridectomy was usually necessary. A better method was that of Work Dodd, who burnt a horseshoe-shaped zone around the apex, the peripheral portions reaching the limbus.

The knife.—Bader was the first to suggest the excision of an elliptical piece of cornea containing the centre of the cone. The instruments required are speculum, von Graefe knife, iridectomy forceps and fixation forceps.

The centre of the cone should be scratched with a needle and stained with fluorescin. The cornea is transfixed with the von Graefe knife in the horizontal meridian about 1 mm. above the cone, the puncture and counter-puncture about 6 mm. apart ; the section is completed with the edge of the knife looking forwards. The lower lip of the wound containing the cone is seized with the iridectomy forceps and excised by cutting from without inwards. The fragment of cornea excised should be about 2 mm. in width where the forceps hold it and pointed at the extremities. The lips of the wound should approximate when the eye is bandaged.

The complications which may arise are iris prolapse and delayed healing. To avoid iris prolapse the pupil must be dilated with atropine both before and after the operation.

Another operation which avoids the delayed healing of the wound is to make a crucial incision without removing any corneal tissue. The horizontal incision is made through the centre of the cone about 6 mm. in width. A 3 mm. vertical incision is then made in the centre of each lip with de Wecker scissors, whilst the lip is lifted away from the lens by means of a repositor. Great care must be taken to keep the iris from becoming entangled in the wound, by using atropine before and after the operation.

Corneal transplantation.—This operation may be undertaken for an eye that has an opaque cornea from past inflammation, if the scar is permanent and the eye otherwise not affected. The graft may be obtained from the patient's other eye should this eye be blind from some other cause and the cornea transparent, or from a donor of the same blood group.

Tudor Thomas has been the most successful operator on such cases in this country. With a 4 mm. trephine he cuts about halfway through the cornea and then, tilting the trephine, cuts through the cornea at one place only and completes the circle with scissors. He aims at securing a graft which is more extensive on the anterior surface than on the posterior. The opaque cornea is treated in a similar manner. A graft of such a shape cannot possibly slip into the anterior chamber. It is held into its bed by conjunctival flaps, or by separating the conjunctiva all round the limbus and tying this with a purse-string suture.

The difficulty of obtaining a transparent cornea as a source of the graft has been overcome by Filator (Odessa), who claims that eyes removed immediately after death can be preserved for at least 6 days near freezing-point, if covered with blood obtained from the dead body. Filator states that the results of transplanting a disc from such an eye compares favourably with results from using a living eye.

OPERATIONS ON THE IRIS AND LENS

Optical iridectomy.—The indications are :—(1) Dense central corneal opacities ; (2) small dense lamellar cataracts ; and (3) pupil blocked and fixed by posterior synechiæ.

If the pupillary portion of the cornea is more or less opaque, and clear cornea is present towards the limbus, an iridectomy behind the clear portion should improve vision. The iridectomy should not extend to the iridic angle owing to the distortion caused by the edge of the lens, and in many cases it is better not to divide the sphincter. What is required is a " button-hole " in the intermediate zone of the iris. This can be done by making a keratome incision of about 8 mm. just behind the limbus ; with curved iridectomy forceps a piece of iris is seized at the required position and, with blunt-pointed de Wecker scissors, can be removed without dragging the rest of the iris into the wound.

With small dense lamellar cataracts when the vision is much improved with a dilated pupil, a small iridectomy to include the sphincter and intermediate zone downwards and slightly inwards, is indicated.

If the pupil is blocked and adherent to the lens, a piece of iris can often be drawn out of the wound by a Tyrrel blunt hook when iris forceps would fail.

If the lens is absent an iridotomy with two Ziegler knives must be done.

Anterior synechiæ.—Anterior synechiæ may require division. This operation is quite simple if the adhesion consists of a thin, stretched band in an anterior chamber of normal depth. A narrow linear knife is made to enter the anterior chamber at the limbus and swept across the band. If a considerable part of the iris is entangled in the wound, a different procedure must be adopted, to avoid injury to the lens. Two knives of equal size are required, one with a sharp and the other with a rounded point—Lang's twin knives. A point is chosen at the limbus from which the knife can pass between the cornea and iris beyond the adhesion. A puncture is made at this point with the sharp-pointed twin and the other knife is inserted and passed into the required position and the adhesion divided by short sawing movements.

Fuchs's 4-point puncture.—In chronic recurrent iritis complete adhesion of the pupillary margin to the lens may take place. In such cases no fluid can pass through the pupil and, in consequence, the intermediate zone of the iris is pushed forward, leaving a funnel-shaped attachment to the lens. The iridic angle becomes blocked and secondary glaucoma supervenes. This condition can be relieved by the passage of a linear knife from one side to the other in the median horizontal position. The knife should enter at the limbus, appear in the funnel-shaped depression of the iris, and re-appear at the limbus on the opposite side when it is withdrawn. This will allow the iris to fall back into its normal position, and on subsequent examination four small punctures will be seen, two on each side of the blocked pupil. By this means the glaucoma is relieved and any further operation such as iridectomy can be safely and more easily performed.

CATARACT

Surgical anatomy.—The lens consists of a mass of transparent fibres surrounded by an elastic, structureless capsule. Immediately beneath the anterior surface of the capsule is a layer of cubical cells from which the lens fibres are derived. These cells are of extreme importance, as they remain with the capsule after the lens has been extracted, and may form new fibres, necessitating an operation for after-cataract.

As age advances there is a tendency for the central part of the lens to become more dense, and in this way a nucleus is formed.

Cataract may be divided clinically into hard and soft, according to the age of the patient ; below the age of 35 there is practically no nucleus, and the cataract is soft ; after 50 the nucleus is sufficiently marked to necessitate complete removal of the lens. In soft cataracts, if the lens capsule be opened to allow the entrance of the aqueous to the lens fibres, the fibres swell up and are slowly absorbed. Up to the age of 35 this method suffices, but after that age the lens fibres do not easily absorb and extraction is advisable. Between the ages of 35 and 50 extraction is difficult, owing to the sticky character of the lens cortex, and much of the cortical matter is likely to be left behind.

The removal of the lens in its capsule has obvious advantages. Some medical officers of the Indian Medical Service operate on thousands of cases a year, and have brought this method of operating to a very high standard. When successful, it means that no after-cataract can form, and so, on that account, it is most suitable in a country where patients may have to travel a thousand miles to seek advice.

The operation used to be much more difficult, dangerous and painful than the ordinary one, but by newer methods of control of the patient, such as anæsthesia of the orbicularis muscles and deep injection of novocain behind the eye, all pain is removed and the danger much reduced.

Senile cataract is usually bilateral. An operation on the more advanced cataract is not advisable until the better eye has lost so much vision that the patient is unable to read, or is obliged to give up his occupation. When cataract is unilateral, no operation should be attempted unless some complication has arisen, such as secondary glaucoma, produced by swelling of the lens.

Previous to 1750 the only recognized operation for cataract was couching, *i.e.*, dislocation of the lens backwards into the vitreous, and even now this method is followed by certain unqualified practitioners in India. The immediate result is excellent, but frequently vision is lost from cyclitis, due to the presence of the lens in its new position, or from glaucoma. For these reasons couching is not justifiable unless there is some complication which makes extraction too dangerous, such as lunacy or chronic incurable dacryo-cystitis.

The incision.—For this a special knife is necessary ; that originally devised by von Graefe is the best. The section is made above, so that if an iridectomy should be necessary the upper lid will hide the disfigurement. When the puncture has been made (*see* below), and the knife is seen to pass across the anterior chamber, the operator must remember that the knife is really deeper than it appears, and the counter-puncture is therefore often made too far back. To prevent this, as soon as the point of the blade disappears behind the limbus on the nasal side the handle should be lowered slightly to bring the point forward. While the section is being made the iris may fall over the edge of the knife ; to remedy this, and to assist the iris to slide behind the cutting edge, lift the eye forwards on the knife and continue the to-and-fro movement; that portion of the knife in the anterior chamber will bow slightly forwards and thus give more room for the iris to slip back.

Iridectomy.—There is much divergence of opinion whether an iridectomy should be performed or not, some holding strongly that a complete iridectomy should always be done, whilst others, admitting the necessity in certain cases, claim that the advantage of a simple extraction more than outweighs the slight danger of prolapsed iris, more particularly as prolapse of the capsule is almost impossible unless an iridectomy has been performed. A great number of surgeons now believe that the best and safest routine treatment is to do a simple extraction, and as a final stage a small peripheral iridectomy. This has most of the advantages, and reduces the disadvantages to a minimum, as subsequent prolapse of the iris is extremely improbable.

Incision of the capsule.—This is of great importance, and demands the closest consideration. Two results are to be aimed at: (*a*) to prevent any flap or tag of capsule becoming prolapsed into the wound; (*b*) to make a central opening in the anterior capsule for visual purposes. Both results can be obtained by the complete removal of the anterior capsule by capsule forceps. Special forceps are made for the purpose; they are passed closed into the lower part of the anterior chamber, then opened, and pressed lightly on to the capsule; when they are closed, the capsule should be found to be held firmly; then with slight lateral movements they are slowly withdrawn. This is a somewhat difficult manœuvre, and a beginner should acquire the necessary dexterity at first with a cystotome.

In opening a capsule with the cystotome, a good method is to pass the instrument on its side to the lowermost part of the lens, then to rotate the instrument so that the point looks backward, and to make a long vertical cut in the capsule; this will ensure a clear opening behind the centre of the cornea, but it will not allow the easy escape of the lens, and for this purpose a horizontal cut should also be made as high up as possible.

A crucial incision has been advocated, but however this is done a fold of capsule can easily reach the wound. A triangular cut in the capsule is theoretically sound but practically dangerous, as it is impossible to be sure that the triangle is completed.

It is obvious that the ideal operation is the removal of the lens in its capsule, but this is difficult and certainly more likely to be followed by prolapse of the vitreous. In certain cases of over-mature cataract the capsule is thickened and the suspensory ligament atrophied; in such cases an attempt should always be made to extract the lens in the ordinary way, but without using the cystotome or capsule forceps.

Extraction of cataract. Instruments.—Speculum; fixation forceps; von Graefe knife; cystotome or capsule forceps; two curettes; iris forceps and scissors; iris repositor; vectis; washing apparatus.

Anæsthesia and akinesia.—The instillation of 5 per cent. cocaine hydrochloride at intervals of three or four minutes for a quarter of an hour is usually sufficient, but in certain cases of extreme nervousness, or if the operation is likely to be painful, an injection of novocain and adrenalin into the orbicularis is advisable to paralyse the muscle and increase the anæsthesia of the lids. The needle must be 30 mm. in length, and is inserted about 10 mm. outside the outer canthus. It is passed along the lower orbital margin close to the periosteum to its full length, and about 2 c.c. is injected slowly as it is withdrawn. The needle is then re-inserted and the upper lid treated in a similar manner.

A complete paralysis of the eye from all sensation and movement can be produced by injecting 1 c.c. of 1 per cent. novocain and 1–12,000 adrenalin chloride into the orbit behind the eye. A needle 40 mm. in length is required and is passed directly backward through the skin near the lower outer orbital margin.

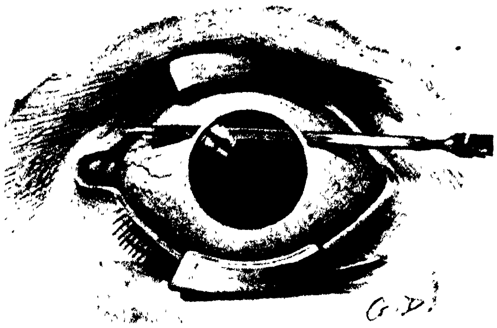


Fig. 656.—Extraction of cataract : puncture and counter-puncture.

Technique.—The patient should be warned on no account to attempt forcibly to close the eye while the speculum is in position. The surgeon stands behind the patient for both right and left eyes and uses the right hand for the incision of the right eye, and vice versa, unless he prefers to adopt the Continental method of standing on the patient's left side for the left and thus using his right hand for the incision. The knife is grasped as if it were a pen, and held horizontally with the cutting edge towards the surgeon, and the little finger rests on the temple close to the upper limb of the speculum. The conjunctiva is seized with the forceps just below the horizontal meridian of the cornea on the nasal side, and close to the limbus. The puncture is made about 2 mm. behind the limbus on the outer side and 3 mm. below the upper limbus, and the knife is directed towards the forceps ; this will prevent the globe from rotating. When the knife has entered the anterior chamber the point is passed horizontally across until it is lost to sight behind the limbus on the other side, then the point is brought forward and the counter-puncture made. (Fig. 656.) By slow to-and-fro movements the knife is made to cut its way out at the upper limbus (Fig. 657) ; as the section is completed the blade should be rotated to a horizontal plane and a conjunctival flap of about 5 or 6 mm. left attached to the anterior lip of the wound.

Incision of the capsule.—The patient is told to look towards his feet. The cystotome, held in the right hand, is passed with the blunt edge forwards to the lower part of the anterior chamber, behind the iris. Then, as already mentioned, it is rotated so that its point looks backwards, and is pressed lightly on the lens capsule, and a long vertical incision made. The pressure used is extremely light, so that very little resistance is felt. The point is now passed under the iris to the left, and a horizontal incision made near the upper margin of the lens.

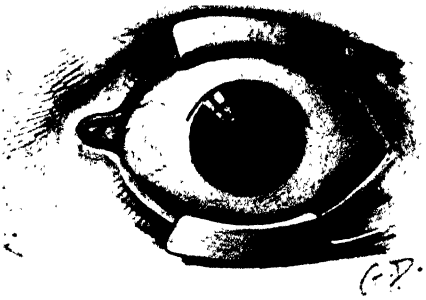


Fig. 657.—Extraction of cataract : section completed.

Delivery of the lens.—A curette is applied to the lower limbus, using the left hand for the left eye, and vice versa ; a second curette is used for counter-pressure just behind the posterior lip of the wound. The direction of the pressure with the lower curette is towards the centre of the eye ; the upper part of the lens is thus tilted forwards, and the increased pressure produced in the vitreous forces the lens towards the incision. Slight pressure is necessary on the posterior lip of the wound to engage the edge of the lens in the wound as it passes upwards, otherwise there is a danger of the lens being pushed up beyond the incision. As the lens becomes engaged in the wound the lower curette follows it, and the pressure is maintained, but its direction changed to upwards and backwards. (Fig. 658.) When the greatest diameter of the lens is engaged the pressure is changed to a gentle following movement as the lens is delivered. Throughout the procedure the iris is disregarded. Should the sphincter of the iris be too rigid to allow the lens to escape, an iridectomy will be necessary ; with curved iridectomy forceps the iris is seized at the sphincter and withdrawn, a narrow piece is removed with de Wecker scissors, held with the blades at right angles to the wound and pointing backwards. It is sometimes found that the difficulty was not really due to the sphincter of the iris, but to failure to open the lens capsule properly.

It is always advisable to remove the speculum as soon as the lens has been delivered; many disasters have occurred from failure to observe this rule. A patient up to this stage may have behaved perfectly, but his self-control may fail him suddenly, and without warning he may contract his orbicularis, an act which is immediately followed by a gush of vitreous. If the orbicularis has been paralysed with novocain this danger is not present.

The speculum having been removed, the upper lid should be drawn back against the edge of the orbit by means of the left ring-finger, and the toilet of the wound completed. By gentle stroking movements of the curette on the cornea any soft lens matter in the anterior chamber may be squeezed out; when this has been done the prolapsed iris is replaced with the repositor. At this stage it is often advisable to use the washing apparatus; it consists of a small flattened silver nozzle attached to about 18 in. of rubber tubing, and this in turn is slipped over the nose of an undine filled with warm saline solution. An assistant holds the undine upside down about 8 in. higher than the patient's head. The surgeon, holding back the upper lid, directs the patient to look down, and, holding the nozzle between his finger and thumb, inserts it gently into the anterior chamber. The force of the current can be controlled by directing the assistant to raise or lower the undine, or by the surgeon pressing the rubber tube behind the nozzle.

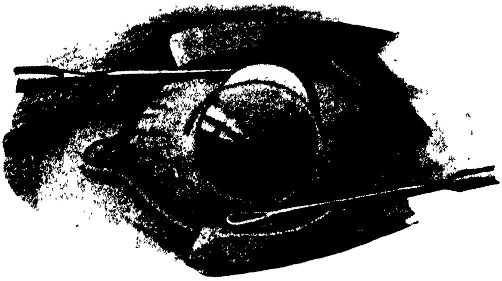


Fig. 658.—Extraction of cataract : delivery of lens.

Peripheral iridectomy.—If the surgeon has been able to reach this stage without removing any part of the iris, a small peripheral iridectomy is advisable. The iris should be in its natural position; if not, the repositor must be used to replace it. The upper lid is drawn back to the edge of the orbit by the left ring-finger, and the straight iris-forceps, held between the finger and thumb of the same hand, are inserted in a nearly vertical direction into the anterior chamber, a small piece of iris is seized and withdrawn to the edge of the wound, and the de Wecker forceps, held in the other hand, cut below the forceps and as close to their points as possible. If the pupil is no longer central the repositor must be used again, but as a rule this is not necessary.

If a conjunctival flap has been cut it must be smoothed back into position, after which both eyes are bandaged and the patient is put to bed.

Complications and difficulties.—It may be found that the patient is too nervous to keep steady ; in such cases the orbicularis must be paralysed, and in addition a deep retro-bulbar injection may be given.

Should the knife be inserted *with the edge downwards* it must be withdrawn and an attempt made to re-insert it ; but if the aqueous has been lost this is difficult, and it is better to postpone the operation for twenty-four hours.

If the lens does not present, this is due either to the capsule not being incised sufficiently, or to rigidity of the sphincter of the iris ; the latter is rare. The cystotome should be used again, and a further attempt made to express the lens ; if it does not present now, a complete iridectomy should be done. *Vitreous may present before the lens,* from rupture of the upper part of the suspensory ligament. In this event the vectis must be used ; while slight pressure is kept up with the lower curette the vectis loop is passed just behind the lens, and far enough for its lower edge to reach beyond the lower edge of the lens ; then, by tilting the handle backwards, and at the same time slowly withdrawing the vectis, the lens can be extracted in its capsule.

The lens may be pushed up beyond the wound, so that its lower edge is level with the middle of the pupil. This is due to insufficient counter-pressure on the posterior lip of the wound. The vectis must be passed in front of the lens with its concavity looking backwards ; the handle of the vectis is then tilted forwards and made to revolve through 90°, and as the upper edge of the lens comes into view it is withdrawn with the vectis. The great danger is that the lens may slip from the vectis and fall backwards into the vitreous. This accident may happen at any stage of the extraction, and necessitates one or two attempts with the vectis loop to fish it out. After two unsuccessful attempts it should be left.

Intra-ocular hæmorrhage.—It sometimes happens that a large choroidal vessel gives way as a result of the sudden reduction of intra-ocular pressure. The extraction is completed without any sign until the toilet of the wound is being done ; then the wound will be seen slowly to open and a large bead of vitreous appears, and when this is snipped off with scissors more and more vitreous shows itself. The eye should be covered with a pad and firmly bandaged. Some useful vision may be restored, but as a rule it will be found the next day that the blood has forced out the vitreous, and even the retina may be in the wound; in such cases the eye must be excised.

Stallard believes that there is less likelihood of subsequent prolapse of the iris and of hyphæma if sutures are used. He passes the sutures before making the section. With a very fine curved needle the first suture is passed horizontally about 1 mm. below the upper limbus and involving the middle third of this portion of the cornea, but not entering the anterior chamber. The needle is then reversed in the needle holder and a similar suture is passed parallel with the first about 2 mm. above the limbus, through the conjunctiva and underlying sclera. The loop is not divided and is left long. The cataract section is then made in the usual manner between the sutures. When the operation is completed the ends of the sutures are drawn tight, to eliminate the loop, and tied. The lips of the wound are thus closely secured. The sutures are left in position for two weeks.

Preliminary iridectomy.—If a patient has lost the sight of one eye as a result of a cataract operation, the operation on the second eye should be performed under different conditions. Two operations should be done: an iridectomy, followed by the extraction some months later. The preliminary operation is useful also in cases of immature nuclear cataract; the subsequent enlarged pupil gives better vision, and in a certain percentage of cases the operation causes maturation of the cataract. Most surgeons prefer a keratome instead of a Graefe knife for the incision, as a smaller opening can be made.

Some surgeons do a preliminary iridectomy in every case of cataract operation, but in my opinion this is not necessary.

With fixation forceps, held in the left hand, the conjunctiva is gripped close to the limbus at the lower end of the vertical corneal meridian. The point of the keratome is placed 1 mm. behind the upper end of this meridian, with the blade nearly at right angles to the globe. As soon as the point is seen to have entered the anterior chamber the handle is drawn back so that the blade is parallel with the plane of the iris, and the keratome is pushed on until a section of about 8 mm. is made. So far no aqueous should have been lost, but as the blade is withdrawn aqueous may escape rapidly and the lens come forward towards the point of the knife. In order to reduce the risk of injury to the lens the handle must be tilted farther back, and the knife withdrawn with the point towards the cornea.

Closed iris forceps, held in the left hand, are passed as far as the upper pupillary edge, and a piece of iris in the sphincter region is seized and withdrawn, and excised with a single snip of the iris scissors, held with the blades at right angles to the corneal incision. The iris usually replaces itself, but if necessary the iris repositor must be used.

Intra-capsular extraction of cataract.—For this operation complete anæsthesia of the lids and eye is essential. After paralysis of the orbicularis and the retrobulbar injection, a slightly larger incision is made than for extra-capsular extraction. The special capsule forceps is passed into the anterior chamber and under the lower edge of the iris, the blades are opened, and the capsule is grasped while pressing the forceps lightly backwards. The forceps is now slowly withdrawn and slight pressure is applied by a curette to the sclerotic just below the cornea. By pressure and traction the lower part of the lens rises into the pupil and by a tumbling movement is drawn into the wound, the lower edge of the lens presenting first. Gentle traction and slight pressure on the centre of the cornea should complete the extraction. The iris is replaced and a small peripheral iridectomy performed. In intra-capsular extraction the peripheral iridectomy may follow immediately after the incision if preferred. In extra-capsular extraction it must follow the removal of the lens, otherwise the lens is apt to be forced out through the iridectomy opening instead of through the pupil.

It must be realized that there is a greater danger of loss of vitreous if the lens is removed in its capsule. In extra-capsular extraction the posterior capsule remains behind to support the hyaloid membrane. With better methods of anæsthesia there is less chance of loss of vitreous being due to movement on the part of the patient, but even so an incidence of about 10 per cent. of vitreous loss must be expected. It is advisable for the surgeon to acquire the necessary dexterity by performing many extra-capsular operations before attempting the more difficult intra-capsular method.

Discission.—Soft cataract may be removed in two ways: (1) By repeated needlings. The injured lens fibres are allowed to swell up and become slowly absorbed after each operation and, when the process has come to a standstill, the lens is needled again. After three or four operations the pupil should be clear. (2) By one free needling, followed by an evacuation of the soft lens matter a few days later. The pupil should have been widely dilated by atropine.

In children under 10 it is better to dispense with a speculum and to hold the lids apart with the fingers of the left hand. The discission needle should be inserted at the upper limbus and passed as far as the centre of the pupil; the capsule is then divided horizontally for a distance of 4 or 5 mm. The needle is withdrawn, if possible, without loss of aqueous. If so much swelling of the lens results that pain and increased tension appear after a few days, the soft lens matter must be evacuated, or if very much soft lens matter comes forward without pain or tension it may be advisable to let it out by linear extraction.

Linear extraction. *Instruments.*—Speculum; fixation forceps; keratome; undine and rubber tube; curette; iris repositor; iris forceps and scissors.

Technique.—In children a general anæsthetic is necessary. After insertion of the speculum the conjunctiva is seized just behind the limbus on the nasal side. The point of the keratome is placed just anterior to the limbus on the temporal side (for the left eye the instrument must be held in the left hand, unless the surgeon stands on the patient's left front), and the blade directed nearly at right angles to the surface. As soon as the point is seen to have entered the anterior chamber the handle is depressed and the blade passed on parallel with the surface of the iris till a section of about 6 mm. has been made. The blade must be withdrawn slowly, as otherwise the gush of aqueous and lens débris may cause the iris to prolapse. The soft lens matter can now be washed out of the anterior chamber.

AFTER-CATARACT

This term is applied to the membrane which so often forms in the pupil after removal of the lens. The term secondary cataract should be used only for those cases of cataract which follow chronic inflammation of the eye.

There are various causes for the formation of after-cataract. It is certain to form if the anterior capsule is not opened in the pupillary area during extraction. It is much less common if the anterior capsule has been removed by capsular forceps, and still less likely if the lens has been removed in its capsule. It is evident, therefore, that the anterior capsule is chiefly responsible. Microscopical examinations of avulsed after-cataract usually show a proliferation of anterior capsular cells forming a thin layer of lens fibres. There are some more transparent after-cataracts which are due to a puckering of the posterior capsule. The more complicated forms of after-cataract are due to inflammatory organized exudation on the surface of the capsule, and are often thick and very tough. The iris may be firmly united to this with the pupil drawn up towards the corneal scar.

The method of treatment depends on the character of the membrane. In the simple forms Bowman's method of cutting a small central opening with two discission needles is sufficient to ensure a good result; but in the complicated forms a special cutting instrument, such as Ziegler's knife, is necessary. This has a very sharp point, a straight cutting edge 7 mm. in length, and a round shank which exactly fills the opening in the cornea made by the blade in order to retain the aqueous humour.

In all cases of needling, two instruments should be used—either two Bowman's discission needles, or one needle and one Ziegler's knife, or two Ziegler's knives—in order to remove the strain of the suspensory ligament on the ciliary processes. The instruments are inserted at the limbus, one up and in, and the other to the outer side; they enter the membrane at the same spot back to back and then cut away from each other; the Ziegler, owing to its length of blade, will allow gentle sawing movements.

Bowman's operation for after-cataract.—With semi-transparent membranes a focus lamp is necessary. The room should be darkened, and the lamp placed in front of the recumbent patient about 45° above the horizontal meridian. The membrane should be examined carefully to note if any dense strands are present. An opening should be made as near the centre as possible, avoiding such strands.

After insertion of the speculum, one discission needle is placed at the limbus, up and in, with its blade parallel with the plane of the iris, the other at the limbus just below the outer horizontal meridian. One needle supports the eye while the other perforates the cornea. With a steady patient, fixation forceps are not necessary. The two needles are made to meet at the site of the proposed opening. One needle perforates the membrane, and as soon as the opening is large enough the other needle enters with it. The blade of the right-hand needle is now made to cut towards the operator while the other needle cuts away from him. In this way a large opening can usually be made.

The needles are withdrawn, care being exercised that the blades should escape as they entered, viz. parallel with the iris, in order to retain the aqueous humour.

If many dense strands are present the operation should be performed in a different manner. The right-hand needle is replaced by a Ziegler's knife. The opening in the capsule should be a little below the centre, and the knife, with the edge towards the operator, by gentle sawing movements, is made to cut upwards while the capsule is supported by the Bowman's needle in the left hand.

In the more complicated cases with dense capsule and adherent iris, two Ziegler's knives should be used. They enter a common opening at the centre of the proposed pupil, back to back, and are then separated by gentle sawing movements until an opening as large as possible is made.

Ziegler's technique.—Ziegler uses one knife only, and enters the anterior chamber through the limbus above. He then passes the knife across the anterior chamber and punctures the membrane below and to the left, and cuts upwards towards the middle line ; he now punctures the membrane again below and to the right, and cuts upwards till he meets the upper end of the previous section. An iridotomy of an inverted V has thus been done. With the point of the knife the apex of the flap is pushed downwards to leave a triangular opening.

The proper use of Ziegler's knives eliminates the more dangerous procedures of making a large opening with a keratome and cutting out a piece of the membrane with de Wecker's scissors.

GLAUCOMA

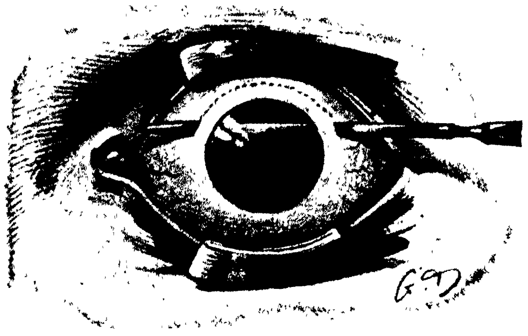
Primary glaucoma, whether due to over-secretion of the aqueous humour, or to its faulty absorption, can only be relieved by operations all other forms of treatment are merely palliative.

In secondary glaucoma the increased tension of the eye is due to exudation into the aqueous chamber of albuminous fluid, which is absorbed with difficulty. The condition is a frequent complication of iritis and irido-cyclitis, and is usually temporary ; as the inflammation subsides under appropriate treatment, the tension returns to normal. When the tension remains high in spite of treatment, an operation is necessary.

In chronic glaucoma an operation should be attempted if there is any decline in central visual acuity not explainable from other causes ; also if the intra-ocular tension does not become normal and remain normal with pilocarpine ; and finally if there is progressive loss of visual field.

We owe the operation of iridectomy for glaucoma to von Graefe, who in 1858 advocated this line of treatment for acute and chronic glaucoma. It is still the operation of choice for the acute form, but for chronic cases the percentage of failure was so high that surgeons have looked for a better means of combating the disease. This has been found in the various forms of sclerectomy. As the name implies, a small piece of sclerotic is removed close to the limbus, and covered by conjunctiva, thus establishing a permanent safety-valve to the anterior chamber.

Iridectomy.—This differs from the iridectomy performed as a preliminary to or during cataract extraction ; in the latter the pupillary portion is chiefly involved and only sufficient iris to prevent prolapse into the wound is removed. If glaucoma is to be cured by iridectomy, as much of the periphery of the iris as possible must be torn away, thus breaking down adhesions at the iridic angle, which in this disease are a serious complication. The operation is indicated in all cases of acute glaucoma, and in secondary glaucoma when the tension cannot otherwise be reduced. If the tension is very much raised, the operation will be made safer by puncturing the sclerotic behind the ciliary region before commencing the operation proper ; otherwise there is danger of rupture of the suspensory ligament and escape of vitreous.



g. 659.—Glaucoma iridectomy : puncture and counter-puncture. Section shown by dotted line.

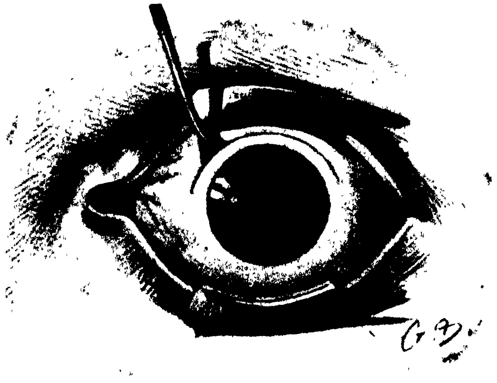


Fig. 660.—Glaucoma iridectomy—iris section : first stage.

As a rule, a general anæsthetic is required in the acute cases.

The incision differs from that made in cataract extraction ; it is not so large, and it is farther back—that is to say, entirely in sclerotic. For cosmetic reasons it is made, of course, in the upper part of the eye. The section is difficult, as, besides having a very shallow anterior chamber across which the knife (von Graefe's) must be passed without injuring the lens, the patient is under a general anæsthetic with his eye rotated upwards. The conjunctiva is grasped with forceps on the nasal side, close to the cornea, and just below the horizontal meridian. The puncture is made about 2 mm. below the upper limbus and 2 mm. from the outer limbus. The knife must at first be directed nearly at right angles to the globe, but when the point is seen to enter the anterior chamber its direction is altered to correspond with the plane of the iris. With a shallow anterior chamber there is less danger of injury to the lens if the point of the knife is carried round the periphery of the anterior chamber before making the counter-puncture, which must correspond in position with the puncture (Fig. 659.) The incision is completed by to-and-fro movements, and kept in the sclera throughout. The final cut should be at least 2 mm. from the limbus. A large conjunctival flap completes the section. The eye must now be rotated downwards, if necessary by an assistant. Closed iris forceps, held in the left hand, are inserted into the anterior chamber, and then opened and made to grasp a piece of the sphincter of the iris ; this is withdrawn and a radial section made with de Wecker scissors on the right side. (Fig. 660.) The iris is torn from its attachment along the whole length of the wound, and freed with a final snip of the scissors. (Fig. 661.) The angles of the wound can be freed from any prolapsed iris by rubbing the cornea with a repositor at each end of the wound, so as to squeeze the iris between the cornea and the lens. (Fig. 662.)

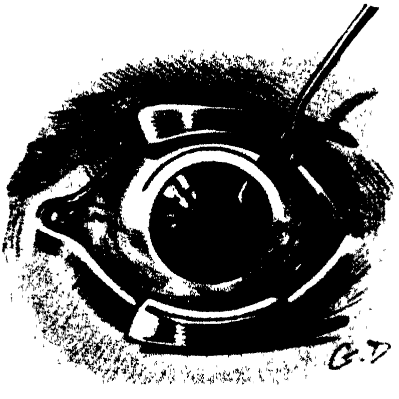


Fig. 661.—Glaucoma iridectomy—iris section : second stage.

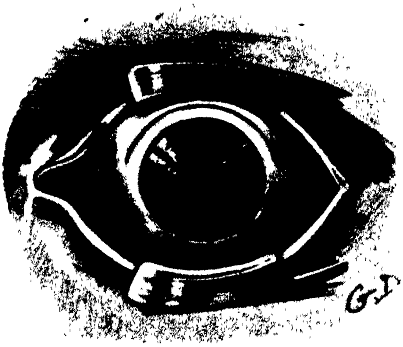


Fig. 662.—Glaucoma iridectomy : operation completed.

It is a good plan when the iris is first seized to attempt an iridodialysis by pushing the forceps with the contained sphincter towards the lower part of the anterior chamber. This gives a better chance of breaking down adhesions at the iridic angle.

In certain cases, when the operation is nearing completion, vitreous will suddenly appear in the wound in increasing quantities ; this is evidence of rupture of a large choroidal blood-vessel, and will almost certainly lead to the loss of the eye. It is due to the sudden relief of pressure, and where disease of the blood-vessels is suspected this danger is somewhat reduced by performing a posterior sclerotomy before the iridectomy.

Posterior sclerotomy.—For this very useful and simple operation local anæsthesia is usually sufficient. The site is a region between the vertical and lateral recti, just anterior to the equator. The eye is rotated in the opposite direction, and at the site of the puncture the conjunctiva is seized with forceps and drawn forwards ; a von Graefe knife, with the blade in a radial direction and the edge posteriorly, is passed about 5 mm. into the eye with a considerable backward direction to avoid the lens. The section having been increased to about 3 mm., the blade is withdrawn, and the conjunctiva will slide back so that the two openings do not correspond. The easiest position for the puncture is down and out, and this will also be out of the way of the subsequent iridectomy. The result of the operation is a slow fall of pressure which may last for twenty-four hours or more.

In cases in which a general anæsthetic is inadvisable, this operation will enable the iridectomy to be performed under local anæsthesia the next day. In all cases in which the tension is much raised, and also those in which disease of the blood-vessels is suspected, iridectomy should be preceded by posterior sclerectomy.

Lagrange's modification of iridectomy.—Lagrange has modified the operation of iridectomy for glaucoma. The puncture and counter-puncture are made to form a section of 6 mm., but the final lip of the wound is brought farther back in the sclerotic by tilting the knife backwards. A large conjunctival flap is cut, turned forwards and freed from the fragment of sclerotic that forms part of the anterior lip of the wound. This piece of sclerotic is removed with scissors, and ordinary iridectomy completes the operation.

In chronic cases a peripheral iridectomy may be preferred. The originator of this operation claimed that it was suitable for all forms of glaucoma. Many continental surgeons prefer it to trephining and claim that the opening in the sclera has a thicker covering and is better protected from possible infection.

The operation of choice in all cases of chronic glaucoma is usually Elliot's trephining.

Elliot's operation.—General anæsthesia is not required and is, indeed, a great disadvantage. Local anæsthesia, even in subacute cases, is sufficient, particularly if a subconjunctival injection of cocaine 4 per cent. and adrenalin 1 : 4000 is given at the site of the operation.

A piece of conjunctiva is seized with forceps about 10 mm. from the limbus in the upper part, and a flap cut with the scissors about

20 mm. in width, curving towards the cornea, but not reaching it by at least 5 mm. This flap must be handled gently; it must be held away from the globe, and freed from the subjacent tissues with sharp-pointed straight scissors up to the limbus. Here it is necessary to split the cornea for a depth of at least 1 mm. This is done with a round-ended knife, such as that of Tooke which resembles a chisel with the corners rounded off. In making this split, the line of separation should lie below Bowman's membrane in order to make the anterior part of the flap as thick as possible. If the cornea is divided sufficiently a small crescent of corneal tissue is seen; this looks dark in comparison with the sclerotic. A trephine (1½ or 2 mm.) is now placed as far forward as possible and, to prevent the conjunctiva being cut by its edge, the membrane should be held at right angles to the globe and parallel with the trephine. When the instrument is in position the conjunctiva should be seized at the left-hand side (if the right hand is used for the trephine) to fix the eye, and with steady rotary movements, the instrument tilted slightly forwards, the disc is cut. The reason for this tilt is that the anterior part may be cut first, leaving the disc hinged by its posterior edge. While cutting the disc the surgeon should keep his eye fixed on the upper part of the iris, for as soon as the anterior chamber is entered, aqueous humour will escape and the iris will come into contact with the edge of the trephine and be moved by it; the instrument must therefore be withdrawn directly the iris shows the slightest movement. A knuckle of iris should then be found to be protruding through the trephine hole, and the disc pushed forwards and held by its posterior edge. The assistant should now draw the conjunctival flap downwards or, if no assistant is available, the flap may be pushed away with closed de Wecker scissors; then with straight iridectomy forceps the iris and disc should be seized together and cut off. The conjunctiva is replaced, and the trephine hole examined through the transparent conjunctiva; its position should be half in the cornea and half in the sclerotic: in other words, the limbus should bisect it. As tags of iris may be entangled in the hole, this region should be massaged with the back of a curette; the iris will thus be squeezed between cornea and lens, and can be manipulated away from the opening, which is better than pushing the end of an iris repositor into the trephine hole.

It is usually advisable to bring the edges of the conjunctival wound together by means of a fine silk suture, which can be removed at the end of five days.

The **difficulties and complications** which may occur during the operation are many. It may be found impossible to dissect up a flap of conjunctiva at the site chosen. In this case a new site must be found where the conjunctiva is not fixed to the globe. To make certain that the disc is not being cut too far back it is advisable to examine the position of the circle as soon as it is marked out, then to replace the conjunctiva in position and note that the circle overlaps the line of the limbus. While the disc is being cut, the trephine must be tilted slightly forwards ; if it is tilted too much the aqueous may escape from a narrow anterior opening in Descemet's membrane through which the iris cannot be made to prolapse. If the trephine is used now there is danger of injury to the lens. The patient should be put back to bed and a subsequent prolapse of iris awaited ; this can easily be removed.

If the trephine is held at right angles to the globe without any tilting, the disc will be completely freed and may escape into the anterior chamber. No harm will result if it is allowed to remain.

Later difficulties.—(1) The bleb may be too large and overhang the cornea, giving the patient a feeling as of foreign body. This is due to the flap being too superficial on the cornea when splitting the cornea. (2) Rapid closure of the trephine hole, usually due to blocking with uveal tissue, results from the trephine hole being too far back. The flap must be turned down again and the trephine hole examined. If it is found to be too far back another trephine hole should be made under the same flap but farther forward and a little to one side of the first opening. When this is completed, and not before, the prolapsed uveal tissue should be removed from the first opening.

Herbert's small flap sclerotomy.—This operation for relief of intra-ocular tension is useful in cases of secondary glaucoma, particularly when following extraction of cataract, or needling for after-cataract. In such cases, if the anterior chamber can be drained for a few days, the eye may regain its normal tension when the inflammatory or other products are allowed to escape.

Instruments.—Speculum, fixation forceps, narrow keratome, blunt-pointed, trowel-shaped knife, iris scissors and forceps, and repositor.

An incision is made with the keratome through the conjunctiva about 6 mm. from the limbus. The keratome is then passed beneath the conjunctiva, the sclerotic punctured about 2 mm. from the limbus, and the anterior chamber entered. The scleral opening should be about 4 mm. in width. The trowel-shaped knife is entered into the anterior chamber on its side and then turned with its edge forward and the sclerotic divided at either end of the keratome incision without injuring the conjunctiva. An iridectomy is not usually required.

Heine's operation.—As many Continental operators dislike the trephining operation, and some substitute must be found for an ordinary broad iridectomy in chronic glaucoma, Heine's operation is becoming increasingly popular. This consists of establishing a communication between the anterior chamber and the supra-choroidal space.

Instruments.—The instruments required are speculum, fixation forceps, scissors, keratome and iris spatula.

A small conjunctival flap about 10 mm. from the limbus is dissected up towards the cornea to expose the sclerotic ; incision is then made with the keratome, at 5 mm. from the limbus, obliquely through the sclerotic. This incision overlies the ciliary body ; care must be taken that the sclerotic only is divided. The spatula is then inserted into the wound ; the point must be pressed against the posterior surface of the sclerotic and pushed forward through the ligamentum pectinatum until it enters the anterior chamber in front of the iris. The iris root can now be separated to the required extent by lateral movements of the spatula. The instrument is then withdrawn and the conjunctiva replaced in position. A conjunctival stitch is not necessary.

Should this operation fail to relieve the increased tension, many Continental operators would as a last resource attempt a trephining operation. In this country most surgeons would do the trephining operation first, and if this failed owing to blocking of the trephine hole, would do Heine's operation behind the trephine opening.

The ligamentum pectinatum can easily be divided from the anterior chamber, as described by Thomson Henderson. He makes a section of the cornea about 7 mm. in length with a narrow Graefe knife, with cutting edge anteriorly. The incision is at right angles to the corneal surface and 1 mm. from the limbus. An iris repositor is passed into the wound and, keeping the round edge against the posterior corneal surface, under the upper lip of the wound, is pushed backwards into the angle of the anterior chamber. Keeping the eye hooked up on the repositor with further pressure, the ligamentum is broken through and separated for the whole length of the corneal incision. The iris, which si contracted by eserine, is unlikely to prolapse ; if it does it can be replaced or excised.

Iridencleisis is performed by some operators in preference to trephining. It consists of embedding a small piece of prolapsed iris under the conjunctiva. The conjunctiva is drawn forward over the upper limbus, and a narrow keratome is then made to enter the anterior chamber at 4 mm. from the limbus, passing through the taut conjunctiva. With iridectomy forceps a piece of iris is drawn out and a tangential part-section of the iris is made, leaving a tag attached at one end. This tag of iris is left outside the wound under the conjunctiva.

RADIUM IN OCULAR DISEASE

In recent years considerable success has followed the use of radon seeds in certain types of intra-ocular growths. In about 25 per cent. of cases of glioma of the retina both eyes are affected. This disease occurs only in early childhood and may be congenital, and if both eyes are affected one eye has always a larger growth than the other. This eye should be removed with as long a piece of optic nerve as possible ; the other eye can then be treated with radium.

A melanotic sarcoma of the choroid of small size in a one-eyed patient can have similar treatment. Before the operation a careful localization must be carried out in a similar way to the localization of the tear in the operation for detachment of the retina. If the growth is very far back it may be necessary to divide an overlying muscle. When the site has been sufficiently exposed, an opening is made with a bent needle and the radon seed is inserted and tied in position ; it is removed at the end of 4 or 5 days.

DETACHMENT OF THE RETINA

The treatment of this condition has become much more successful of recent years owing to the work of Gonin, and an operation is now advisable, as the chances of recovery of sight after operation have improved from about 5 per cent. to 30 per cent. if the patient is not too old and the detachment recent and not too extensive.

The retina is developed from the two layers of the primitive optic cup, and there is, therefore, a potential space between the two layers. What actually occurs is a separation of these two layers by fluid passing into the space ; the inner nervous layer floats towards the vitreous while the outer pigment layer remains attached to the choroid. In some part of the detached retina there is usually a hole or else a separation from the ora serrata. Gonin maintains that this hole or disinsertion must be closed at the time of the operation to effect a cure. The difficulty is to decide what place in the sclerotic would correspond with the retinal rent when the retina is replaced in position after removing the sub-retinal fluid. Many elaborate instruments were devised for this purpose, but with new methods of operating such extreme accuracy is not so necessary, as a much larger area is attacked than the single cautery puncture of Gonin.

Gonin's operation.—The tear in the detached retina having been found, careful measurements must be made to determine the exact position on the sclerotic where the puncture is to be made. A sub-conjunctival injection of novocain and adrenalin is given in this region. A curved incision is made through the conjunctiva and Tenon's capsule, about 12 mm. from the limbus and 20 mm. in length, and is dissected up until the required position in the sclerotic is exposed. A thermo-cautery with a rather fine point is now heated to a white incandescence. An incision is made in the sclerotic with a von Graefe knife and the sub-retinal fluid allowed to escape as completely as possible. The cautery is now pushed into the scleral wound for a distance of 4 mm. and is allowed to remain in position for not more than two seconds. The conjunctiva is replaced and sutured in position. Both eyes are bandaged and the patient kept in bed for one or two weeks. The result will depend on whether the tear in the retina has been sealed by the cautery.

To overcome the difficulty of hitting off the tear with the cautery, many operators now use a barrage of small cauterizations surrounding the area of the tear. A diathermy apparatus is used with needle points not more than 2 mm. in length and a current of 30 m.a. The needle is made to enter the sclerotic with the current on and is withdrawn after two seconds. As many as 20 or 30 insertions may be made and, if insufficient sub-retinal fluid is escaping, an incision can be made with a narrow knife to allow its complete escape.

EXCISION OF THE EYE

This operation is one of the easiest in ophthalmic surgery, and any medical man should be able to perform it, more particularly as the removal of a badly damaged or painful blind eye may be urgent.

The chief reasons for removal of an eye are :

1. The presence of an intra-ocular malignant growth.
2. A perforating wound of the eye, severe enough permanently to damage the sight, and of a character likely to produce sympathetic inflammation in the other eye.
3. An eye that is blind and painful.

As sympathetic inflammation has never been known to occur if the eye is removed within ten days of the injury, it is in most cases wise to wait a few days before making the final decision. There are, however, certain injuries which are so severe that delay is useless.

Anæsthetic.—The operation requires either a general anæsthetic or a deep retrobulbar injection of novocain.

Instruments.—Speculum, fixation-forceps, strabismus scissors, squint hook, large curved scissors, needle-holder, needle, and suture.

Technique of excision.—After insertion of the speculum, the conjunctiva is seized with forceps close to the limbus on the right-hand side, a small incision is made, one blade of the scissors inserted into the opening, and the conjunctiva divided as close to the limbus as possible ; this procedure is followed till the conjunctiva is free all round. With the closed scissors, Tenon's capsule can be opened up, and any adhesions divided. Each of the recti is now lifted on the squint hook and divided between the hook and the globe. The screw of the speculum should be loosened and the speculum pressed backwards, so as to dislocate the eye forwards. The large scissors, closed, are passed between the conjunctiva and the globe on the right-hand side to the back of the eye, the optic nerve is felt for, and, having located this carefully, the surgeon withdraws the scissors sufficiently to allow them to open, and then divides the nerve close to the globe. The eye can now be held between the finger and thumb of the left hand, and the oblique tendons divided as the eye is withdrawn. This is often followed by free hæmorrhage, which can be controlled by placing in Tenon's capsule a plug of gauze, to be changed two or three times and then removed. The conjunctiva is brought together, but not so firmly that blood is unable to escape. A large dressing is placed on the outside of the lids, followed by a firm bandage, and the patient is put back to bed.

Certain modifications are required in exceptional circumstances. If the eye has a large wound in it, a strong suture should be passed through both lips of the wound and given to an assistant, who must draw the eye slightly forward by means of this suture and keep it so throughout the operation.

When glioma of the retina is suspected the optic nerve must be divided as far back as possible. In this form of tumour the invasion of the extra-ocular tissues is invariably through the optic nerve. The nerve can be freed from the surrounding tissues for a considerable distance by the closed scissors ; then, with the dislocated eye drawn forward with the finger and the scissors pressed back as far as possible, the nerve may be divided 12–16 mm. behind the globe.

As the lymph spaces connected with the dura mater are opened on dividing the optic nerve, the operation of excision, in cases of acute suppuration of the eye, may be followed by septic meningitis. Although this rarely happens, it is advisable in such cases to leave the sclerotic attached to the optic nerve and to remove the rest of the eye. This is called evisceration. Some surgeons prefer this operation in all cases, as it leaves a much better stump for the artificial eye.

Evisceration of the globe.—The conjunctiva is divided as for excision, and Tenon's capsule opened up with strabismus scissors, but no muscles are divided. An opening is made in the globe with the scalpel about 10 mm. behind the limbus, and the sclerotic is divided by scissors all round at about this distance. This piece is removed, and contains the cornea, iris, lens, and ciliary body. The contents of the rest of the globe are removed by means of a piece of wool wrapped round a pair of forceps while the sclerotic is held forward ; this is repeated until all pigment is removed and the cup-like cavity can be seen white and glistening. This completes the operation in septic cases, but when no pus is present in the vitreous the conjunctiva can be brought together over the collapsed sclerotic.

It is obvious that, in aseptic cases, if something were put into the sclerotic, and the edges brought together, a much better cosmetic result might be obtained. In 1885 Mules published his operation, in which he inserted a glass globe into the cavity. When successful the results of this operation are excellent, but a great number of the globes are extruded. The incision of the sclerotic has to be a double ellipse instead of a circle ; the upper and lower lips are only about 2 mm. from the corneal margins.

The scleral lips should be sutured with catgut, making a horizontal line, and the conjunctiva brought together with silk to form a vertical line. The globe should not be more than 10 mm. in diameter.

Abscission.—This operation, devised by Critchett in 1863, is seldom performed now, as it is considered likely to cause sympathetic ophthalmia. Its chief use is for blind eyes suffering from staphyloma of the cornea. The anterior segment of the eye is removed, as in Mules's operation, but the vitreous is to remain. The conjunctiva is divided, and Tenon's capsule opened up as for evisceration. Four large curved needles are passed vertically at intervals of about 6 mm., the two central ones passing behind the cornea. Each needle enters the eye about 10 mm. behind the upper limbus and reappears 10 mm. from the lower limbus. The head of each needle lies just behind the site of the upper part of the incision, and the points just behind the lower incision. The needles are left in position until the anterior segment of the eye has been removed. The incision must be farther back than in the operation for evisceration, so as to remove the ciliary body. An opening is made with the scalpel, and the incisions are completed with scissors. Catgut sutures are inserted into the eyes of the needles, the needles withdrawn, and the sutures tied. The operation is then completed, as in Mules's operation, by bringing the conjunctiva over the wound to make a vertical line of sutures.

Frost's operation.—In 1885 Frost advocated, as an improvement on simple excision of the eye, the insertion of a hollow glass sphere into Tenon's capsule. The sphere, when retained, gives an admirable stump for an artificial eye.

After removal of the eye, Tenon's capsule should be filled with a plug of wool, while a purse-string suture is inserted about 5 mm. from the edge of the wound. The plug is removed, and replaced by the glass sphere, which should not be more than 10-12 mm. in diameter. The purse-string suture is tied tightly and a pad and bandage applied. A rather large proportion of the globes is extruded at the end of a week or ten days, probably owing to slight septic infection from the conjunctiva.

Operations for cases unsuitable for artificial eye.—The removal of the lid margins, conjunctival sac, and tarsal cartilages is indicated in certain cases where an artificial eye cannot be worn. It is advisable in malignant disease of the lid margins involving the eye, and in extensive injuries of the lids and eye, also in lunatics who cannot be trusted with an artificial eye.

The eye is excised in the ordinary way, the speculum is removed, and an incision made with the scalpel, about 3 mm. from the lid margin, in the skin of both lids, beginning at the inner and meeting at the outer canthus. The external tarsal ligament is divided with scissors. The lid margins, with the whole conjunctiva, are now drawn towards the inner canthus and freed from the subjacent tissues by means of the scissors, and finally removed by dividing the mass at the inner canthus. The canaliculi are included. The skin margins are then brought together. The result is a perfectly smooth surface. The lacrymal gland has not been interfered with, and may cause recurrent attacks of swelling for a few months.

Exenteration of the orbit.—In malignant disease the whole contents of the orbit may have to be removed, and if the bony walls are involved the periosteum must also be sacrificed.

After inserting the speculum the surgeon divides the outer canthus with curved scissors up to the edge of the orbit. The fornices of the conjunctiva are opened up above and below with the scalpel by incisions meeting at the inner and outer canthi. The eye is drawn forwards and inwards and the contents of the orbit are freed from the outer wall by repeated cuts with the scissors as far back as possible. The lower, inner, and finally the upper walls are treated similarly, and when the whole mass is free it is drawn forwards and finally separated from the apex of the orbit. The free hæmorrhage which usually follows is controlled by packing the orbit with gauze. If the periosteum is to be removed a rugine will be required. The incision through the fornices of the conjunctiva is continued up to the edge of the orbit, where the periosteum is divided. It is firmly attached at the margin, but elsewhere is easily freed from the orbit. The operation should be completed by removing the edges of the lids and the palpebral conjunctiva. The skin will form an admirable protection for the anterior part of the orbit.

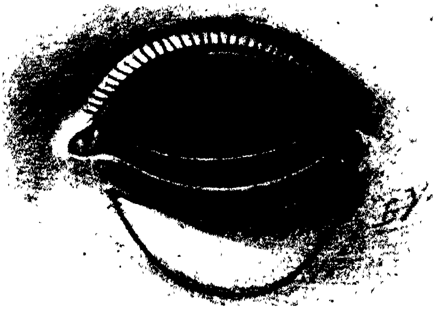


Fig. 663.—Maxwell's operation.

Maxwell's operation.—It is often found impossible to wear an artificial eye owing to the lower cul-de-sac being too shallow to retain its lower edge. Maxwell has devised an operation for deepening this cul-de-sac. An incision is made at the lower part of the cul-de-sac in length nearly equal to that of the lower lid, and in depth about 6 mm. throughout. (Fig. 663.) An incision is then made in the skin about 5 mm. below the lid margin and a little larger than the conjunctival incision ; from each end of this a curved incision extends downwards, meeting at a point 12 mm. below the centre of the first incision. The upper skin-incision is made to join the conjunctival incision. The lower skin incision is deepened obliquely upwards to form a pedicle for the crescentic island of skin. This crescent is pushed upwards under the bridge formed by the lid margin, and its upper edge attached to the posterior edge of the conjunctival wound by several sutures. (Fig. 664.) The lower edge of the crescent of skin is pushed up still farther and attached to the anterior edge of the conjunctival wound (i.e. the posterior border of the bridge). The skin-wound is then closed by horsehair sutures.

At the present time greater success is obtained by planting an epithelial graft in the socket after removal of all conjunctiva. A mould of the cavity is taken with dental wax softened by heat. A skin-graft is cut from the inner side of the upper arm or thigh, of sufficient size to wrap round the graft completely, with the raw surface outwards. After dividing the outer canthus with scissors, the covered graft is placed in the socket with the line of graft-overlap parallel with the palpebral fissure. The outer canthus and middle line of the lids are sutured. At the end of a week the lid-sutures are removed but the mould must remain in position for two weeks ; it can then be removed and replaced by a smaller mould. At the end of another four weeks this mould can be replaced by an artificial eye.

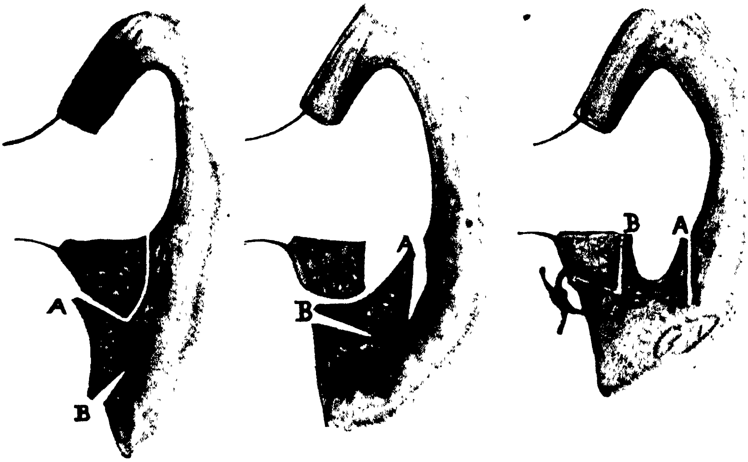


Fig. 664.—Maxwell's operation.
A, B, the skin crescent.

FOREIGN BODIES IN THE EYE

Diagnosis.—It is an axiom that every eye with a perforating wound should be considered to contain a foreign body unless the patient can prove the contrary.

Much assistance can be obtained from an X-ray photograph. It must be remembered that some substances are transparent to X-rays —for instance, most forms of organic matter, glass and stone.

Electro-magnets are useful if the body is of iron or steel, but certain steels are non-magnetic, viz. manganese and chrome.

If the lens be uninjured, the fundus clear of blood, and the foreign body situated posterior to the equator, it may be seen with the ophthalmoscope and its position located.

Finally, there are certain cases, e.g. an eye that has been injured by a piece of stone, causing a traumatic cataract, in which X-rays and the magnet are useless, and the diagnosis must be made from the clinical progress of the case.

The danger of sympathetic ophthalmitis.—The treatment of the eye will vary a good deal according to the condition of its fellow. If the injured eye is the only useful one, the surgeon should consider only the saving of some vision in it. In most cases, however, the other eye must be the important consideration and the injured one must be removed at the end of two or three weeks if the inflammation is not rapidly subsiding. The presence of a foreign body in one eye used to be considered a certain cause of sympathetic ophthalmitis in the other. This is not quite true. There are some substances, such as glass, lead, and aluminium, which cause no irritation and are therefore not very dangerous if sterile ; but other and oxidizable substances, particularly copper, cause severe irritation, and unless these are removed within a few days the eye may be lost and the other eye incur great danger of being blinded by sympathetic inflammation. The appropriate treatment of the injured eye will depend, therefore, on various factors, the most important of which are the position of the foreign body, its character, and the length of time that has elapsed since the injury.

Position of the foreign body.—If it lies in the anterior chamber, the foreign body may be removed by a keratome incision and iridectomy forceps. If it is embedded in the lens it is better to wait until a traumatic cataract has formed, and then to remove the lens with the foreign body. In most cases it is situated in the vitreous, and as it is usually of a higher specific gravity than this fluid, it will sink to the lower part of the fundus. It is in such cases that the character of the substance is of such vital importance, for unless it is of magnetic steel or iron its removal is extremely difficult.

If two weeks or more have elapsed since the injury, and the eye is known to contain a foreign body (the other eye being sound), and is inflamed and painful, the organ should be excised without delay ; but if the injury is more recent an attempt should be made to remove the foreign body.

The exact position of a foreign body which is opaque to X-rays can be determined with perfect accuracy by photographs taken at different angles. This, however, causes some delay, and if a giant magnet is available it is better to place all patients with perforating wounds of the globe in front of the magnet to determine if the foreign body is magnetic or not.

Magnet operations.—Two kinds of giant electro-magnets are at present available : the Haab, and the Mellinger or ring magnet ; the latter is preferable. With the Haab magnet the patient must sit facing the point of the instrument. With the ring magnet the patient lies on the operation table and the magnet is placed so as to encircle his head.

As the pull of the magnet varies inversely as the square of the distance, and is directly proportional to the weight of the foreign body, great care must be exercised on first testing the eye with the magnet.

If the foreign body is large and magnetizable, much serious damage may be done if the eye is placed too close to the Haab, or if full current and a large rod are used with the ring magnet. With the latter the weakest current and the smallest rod should be tried first; if the patient feels nothing with the point of the rod touching the eye, the current should be increased gradually, and then the rods changed until the largest has been used. If still no pain is felt and no movement of the eye is seen, any foreign body present must be considered non-magnetic.

In making a diagnosis with the Haab magnet, the patient should be placed with the eye 8 in. from the point when the current is first turned on. If there is no result the current should be turned off, and the patient placed at 4 in., then at 2 and at 1 in.; if there is still no result, the cornea should be made to touch the point of the magnet, and finally the ciliary region above and below and to either side is brought into contact with the magnet, before a negative result can be accepted.

If the injury was inflicted within twenty-four hours, and the wound is in the ciliary region or behind it, an attempt should be made to remove the foreign body through the wound. In most cases, unless it is large, the anterior route will be selected, and the foreign body drawn forward through the suspensory ligament, and then through the pupil into the anterior chamber. Finally, a keratome incision will enable the operation to be completed.

The pupil should be dilated with atropine, the lids and eye carefully washed, and the points of the magnet sterilized. Local anæsthesia is usually sufficient, but as a general anæsthetic may be necessary the patient should be prepared accordingly.

The anterior route. *The Haab magnet.* The patient is seated on a stool so adjusted that the eye is level with the point of the magnet, and his head, covered with a towel, is supported against the surgeon's left shoulder. The upper lid is raised by the surgeon's left thumb and the lower depressed by the right thumb. No speculum is used. A brilliant light must shine on the eye, preferably from the left. The eye is brought slowly towards the point of the magnet until pain is felt, the current being turned on only for a few seconds at a time. The eye is kept at this distance, with the magnet pointing to the centre of the cornea, while the current is turned on and off as before; the iris must be watched carefully for movement, which is usually seen below. When this occurs the direction of the pull must be altered in order to draw the foreign body through the pupil. If the movement of the iris is below, the patient must look down so that the magnet points to the upper limbus.

The operation of removal of the foreign body from the anterior chamber is proceeded with as soon as it is drawn through the pupil, and also if it fails to enter the anterior chamber, through being entangled in the iris, after three or four minutes' trial with the magnet. The instruments required are a speculum, fixation-forceps, and repositor.

The patient is placed on the operating table, and a general anæsthetic may be necessary if he has become restive under the previous manipulations. The lids and eye are washed again, and the speculum inserted. An incision is made with a keratome at the limbus, and at the site of the foreign body. The point of the magnet is brought as near as possible to the patient, and the intervening distance overcome by raising the patient's head till the corneal incision is in contact with the point. The lips of the wound are separated by the non-magnetic repositor and the current turned on, when the foreign body will escape and be found adherent to the point of the magnet. If the foreign body is behind the iris, before raising the patient's head a small peripheral iridectomy should be done where the iris had previously been seen to move ; the foreign body will then escape through this opening when the current is turned on.

The ring magnet.—The patient lies on the operating-table, and is therefore not so liable to faintness as with the Haab magnet. The ring is adjusted so that the injured eye lies in the centre of the solenoid. A speculum is used. The weakest current is turned on and the smallest rod is brought slowly towards the centre of the cornea ; the current is increased to the maximum and larger rods are used until a positive result is obtained ; the foreign body is then brought forward as with the Haab, the direction of the current being changed when the iris is seen to move.

When the keratome incision has been made, a small magnetic spatula is inserted into the anterior chamber and made to touch the foreign body ; the current is then turned on, and the piece of metal removed.

The posterior route.—In all recent injuries of the sclerotic where the presence of a foreign body in the vitreous is probable, the wound should be exposed to the pull of a giant magnet with as little delay as possible.

When the original wound has healed, and an X-ray photograph can be obtained without more than twenty-four hours' delay, it is better to postpone the operation until the position of the foreign body can be determined exactly. An incision is then made in an antero-posterior direction as close as possible to the site of the foreign body.

The instruments required are a speculum, fixation-forceps, scalpel, scissors, needles, and needle-holder.

A conjunctival flap must be cut so that the conjunctival sutures will not correspond with the deep scleral sutures. When the sclerotic is sufficiently exposed, two sutures are inserted in its superficial layers parallel with and on each side of the proposed incision. These sutures, if held by an assistant, will prevent loss of vitreous and, when the operation has been completed, will enable the wound to be closed quickly. The sclerotic is now incised between the sutures for a distance of about 10 mm. The choroid and retina must also be divided to give access to the vitreous chamber. The point of a small hand electric magnet may now be applied to the scleral wound, but the result is usually negative, and the giant magnet must then be placed in position. If the Haab magnet is used it must be brought as near as possible to the patient, and his head raised so that the wound comes close to the point. With the ring magnet the weakest current is turned on and the smallest rod brought slowly to the wound ; the current is increased and the rods are changed until the foreign body is removed.

If the X-ray photographs have proved the presence of a foreign body which cannot be removed by the magnet, an attempt must be made to seize the object by means of small straight iridectomy forceps.

OPERATIONS ON THE BONES OF THE ORBIT

A growth behind the eye should be removed as early as possible, or pressure may produce atrophy of the optic nerve.

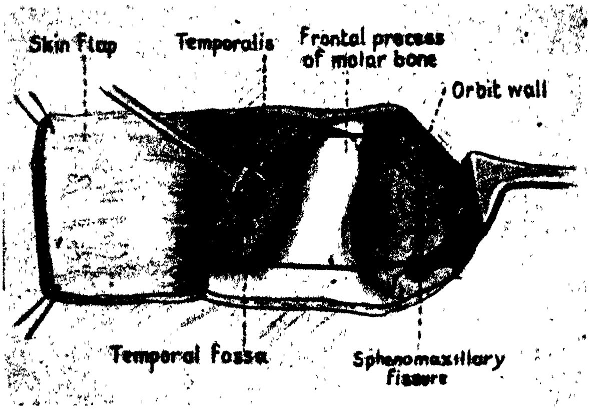


Fig. 665.—Kronlein's operation : the field of operation.

Showing the saw cuts for the removal of a quadrilateral piece of bone from the outer wall of the orbit. (Reproduced, by permission, from *The Lancet*, Jan. 15, 1938.)

If the tumour can be felt, an incision about 30 mm. in length should be made along the margin of the orbit close to the tumour and down to the bone ; the orbital fascia should be separated from the bony margin and the space between the bony wall and orbital contents opened up. The tumour should be examined with the finger and its depth determined. In many cases tumours are encapsuled, particularly those in the upper and outer part of the orbit associated with the lacrymal gland, and complete removal by enucleation, assisted with a few snips of the scissors, is not difficult.

If the tumour extends to the back of the orbit and the eye is to be saved, a more extensive operation must be undertaken to obtain more room. If the eye is blind it should be removed and the tumour dealt with afterwards by a complete or partial exenteration of the orbit.

Kronlein's operation.—The eye may be saved by Kronlein's operation ; this involves the temporary resection of the external orbital wall. (Fig. 665.)

Instruments.—Scalpel, large curved scissors, blunt-pointed straight scissors, various forceps, including pressure forceps, periosteal elevator, small chisel and mallet, retractors, orbital spatula, needles, needle-holder, catgut and silk sutures.

Operation.—A curved incision with convexity forwards is made, commencing about half an inch above the external angular process of the frontal bone and extending to the middle of the zygoma. The upper part of the incision follows the orbital margin, and here the incision is carried down to the bone. The periosteum along the margin of the orbit is incised, and separated by the periosteal elevator from the greater wing of the sphenoid. The orbital contents are held away from the bare bone with the spatula by an assistant whilst the spheno-maxillary fissure is located ; the elevator should be inserted into this fissure to act as a landmark. A wedge-shaped piece of bone is cut with the chisel and hammer. The upper incision through the bone begins just below the external angular process and is extended backwards to the elevator in the fissure. The second incision begins at the base of the orbital process of the malar bone and is continued backwards to meet the first incision at the elevator marking the spheno-maxillary fissure. The wedge of bone can now be dislocated backwards without being completely detached, exposing the outer part of the orbital contents covered by periosteum. Sometimes the bone is completely detached, in which case it must be placed in warm saline and replaced after the tumour has been dealt with. The periosteum is incised from before backwards with the blunt-pointed scissors, and a finger is inserted into the wound to explore the contents of the orbit. It may now be necessary to divide the external rectus ; a catgut suture is passed on each side of the proposed incision for subsequent union. A very free access is thus obtained to the orbit, and the growth is removed. After all hæmorrhage is checked, the divided external rectus is reunited and the bone rotated into position. The periosteum is replaced with catgut sutures and the skin wound sutured with silk or horsehair.

CHAPTER XXX

OPERATIONS ON THE NOSE AND PHARYNX

By W. DOUGLAS HARMER

ASSISTED BY

J. CECIL HOGG

INTRODUCTION

Operations in the upper air-passages are very common. They can be simple or extremely complicated. There is always an element of risk, even in the simpler procedures, and no operation should be undertaken without careful consideration. The patient should be overhauled thoroughly to ascertain if he is fit enough to stand shock, particularly if he is very young or old. Preliminary treatment may be necessary if he is debilitated by illness, such as anæmia, or by certain diseases of the heart, lungs or kidneys. When there is any known tendency to bleeding, operation must be postponed for determination of the bleeding time and coagulation time. In doubtful cases all necessary preparations for blood transfusion must be made. Except in grave emergency no operation should be performed on an established case of hæmophilia.

The **anæsthetic** is most important. Unfortunately there are still too many deaths during anæsthesia in throat operations, and most of the recorded cases have been due to chloroform. For children, general anæsthesia, in most cases preceded by some preliminary medication, is nearly always necessary. For adults almost any form of anæsthesia—either local or general—may be employed. When the former is chosen, most patients require a preliminary injection of morphia or hyoscine compound half an hour previously.

Cocaine is still used for surface anæsthesia more extensively than other drugs, in spite of its greater toxicity. Usually a 10 per cent. solution is strong enough for sprays, tampons of wool or ribbon-gauze packing but 20 or 25 per cent. in the form of paint or paste is extensively used for deep anæsthesia.

Two useful formulæ are :—

Cocain. hydrochlor.	20 per cent.
Sol. adrenalin. 1 in 1000 ...	20 ,, ,,
Gum saline 6 per cent.	to 100 ,, ,,

and

Cocain. hydrochlor.	gr. cxx
Supra-renalin	gr. xxv
Chloretone	gr. iii
Paraffin liq.	ʒ iv
Paraffin molle	ad ℥i

Sig. To be used cautiously.

Adrenalin.—For surface application it is usual to add adrenalin, 1 in 1,000, using about 5 drops to 60 drops of the anæsthetic solution, thereby producing better shrinking of the membranes. Cases of sudden death from adrenalin have been reported, especially when chloroform is given as well, an accident which is unlikely if the adrenalin is applied to an unbroken mucosa before the chloroform is given. Adrenalin may also cause faintness. In certain patients adrenalin produces severe rhinitis. The constriction of the membranes is followed by great sponginess and rhinorrhœa, and the surface of the mucosa becomes covered later by a thick fibrinous exudate which takes several days to separate. This may block the nasal passages completely and, if allowed to remain too long, may lead to adhesions, resulting in bridges between the septum and the turbinates. For this reason strong solutions of adrenalin should never be employed, and it should always be used sparingly.

Sluder's trunk anæsthesia is an effective method of anæsthetizing the whole nasal cavity. Two cotton-wool probes soaked in cocaine paste or paint are inserted into the nose for ten minutes, one of them lying against the front of the sphenoid to block the spheno-palatine ganglion, and the other high up on the septum in contact with the nasal nerve. Patients known to be susceptible should never be given cocaine.

Percaine is also a powerful local anæsthetic and has certain advantages. It can be used in weak dilutions such as 1 in 1,000 or 1 in 500.

Novocain is of little value as a surface application, but in strengths of 1 to 2 per cent. is widely employed for injection, and then produces good local anæsthesia.

The use of basal narcotics before general anæsthesia has become almost a routine. If rectal avertin or paraldehyde or an intravenous injection of evipan or penthothal is given, the patient becomes sleepy and has no further anxiety. An intracheal tube can be passed and gas-and-oxygen with a minimum of ether can be given.

The methods of procuring anæsthesia have improved greatly in recent years, making it safer for the patient and easier for the surgeon.

Bleeding is a second serious factor which is never to be forgotten. Many people are just as fearful of it as they are of taking an anæsthetic, because they have heard of some other patient who nearly died from hæmorrhage. It ought almost always to be possible successfully to control hæmorrhage and, even if a great deal of blood is lost, to prevent death from shock. Nasal operations are sometimes attended with severe bleeding and occasionally this is sufficient to cause difficulty in carrying out the treatment that has been planned.

Except for certain conditions which will be indicated later, it is not advisable to plug the nose after operation because it causes discomfort and sepsis. If necessary, strips of ribbon gauze which have been soaked in adrenalin 1 in 1,000, in some simple antiseptic, or in liquid paraffin with powdered bismuth oxychloride, can be introduced through the anterior nares. The nasal fossæ should be packed thoroughly and tightly, passing the ribbon to the sphenoidal region along the floor and then packing the upper and anterior parts of the nose. This prevents the gauze from slipping down into the pharynx. A narrow piece of adhesive strapping applied from side to side around the front of the nose also prevents the patient from dislodging the pack by sneezing. Rarely the posterior nares must be plugged first. A roll of gauze (1½ by ¾ in.) is firmly tied by a double strand of thick silk. A soft rubber catheter is passed through the nose and to the end which appears in the pharynx one of the silks is attached. The catheter is withdrawn from the nose with the silk. The soft palate is retracted with a finger, and the plug is drawn upwards by the silk so that it is firmly impacted inside the posterior naris. To fix it in position the silk can be tied around a second roll of gauze placed just outside the nostril. Usually both posterior nares must be plugged and the gauze retained for forty-eight hours. Such plugging may also be necessary for secondary hæmorrhage occurring several days after operation or for severe forms of epistaxis due to other causes. In certain instances the plugging needs replacement after clearing the nose of blood clot. See also p. 1388.

Shock.—To prevent shock it may be necessary to give the patient an immediate transfusion of blood. In major operations, such as removal of tumours of the jaw, it may sometimes be advisable to perform a preliminary ligature of the external carotid artery. In one instance temporary ligature of both external carotids enabled me to remove successfully a large pulsating angiofibroma, which had been considered inoperable, with hardly any loss of blood or shock from the operation. Secondary hæmorrhage after operations on the jaw or nasal sinuses may be so severe (3 per cent. in my cases) that it can only safely be controlled by ligature of the external carotid and blood transfusion.

Pharyngeal operations sometimes cause bleeding, which may be very alarming and serious if not properly dealt with (*see* tonsillar bleeding, p. 1420). In rare instances, where an abnormal artery, usually the internal carotid, has been divided, there may be fatal collapse before the vessel can be ligatured. When removing adenoids an unfortunate house surgeon actually cut out a complete segment of the internal carotid artery, which no doubt had projected into the naso-pharynx, and the child died in consequence although the bleeding was eventually controlled.

-It is well to remember that the upper air-passages are often very heavily infected with virulent organisms and that, although the patient may not appear to be ill, resistance may be at a low ebb. Considering the great number of operations performed under these conditions, serious complications may be said to be rare, but their possibility should not be forgotten. A simple operation for polypi or for sinusitis may be fatal owing to meningitis. In the pharynx, trauma may be followed by very severe infection and general toxæmia. If blood, mucus or pus is allowed to pass into the trachea, the patient may suffer from serious asphyxia followed by bronchitis, broncho-pneumonia and other lung complications. Fortunately most of these complications can now be successfully controlled by sulphonilamide.

OPERATIONS ON THE NASAL FOSSÆ AND ACCESSORY SINUSES

SUBMUCOUS RESECTION OF THE NASAL SEPTUM

Indications.—This is the operation to choose for the relief of any form of nasal obstruction, whether due to displacement of the anterior portion of the septal cartilage, to spurs, or to a deflection of the septum (Fig. 666) ; for many cases of rhinitis (colds), naso-pharyngeal, Eustachian and laryngeal catarrh ; for certain lung conditions, in patients suffering from air-hunger ; for certain cases of asthma ; for reflex nasal headaches ; and to facilitate the treatment of polypi or ethmoiditis, or intranasal drainage of the frontal sinus and the antrum.

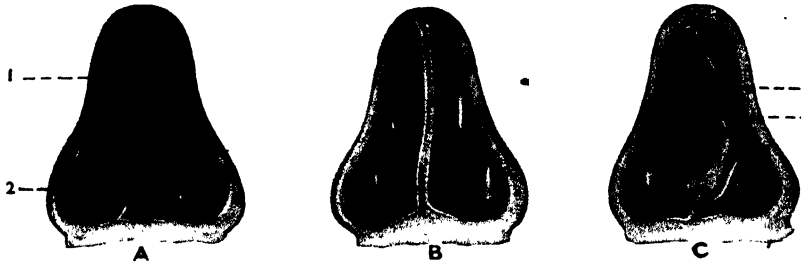


Fig. 666.—Varieties of deflected septum.

A, S-shaped (1, middle turbinate ; 2, inferior turbinate) ; B, posterior spur ; C, simple (1, 2, reflection of flaps).

In children it is rarely performed because of the difficulty of obtaining good results, on account of the small size of the nasal fossæ, and from fear of causing deformity. Whenever possible it is advisable to postpone the operation until the nose is fully developed. Patients over fifty have generally become accustomed to obstruction, and are not likely to be benefited by the treatment. The operation should not be undertaken in those suffering from active tuberculosis, lupus, or syphilis. Septic teeth and diseased tonsils should be removed, and a reasonable interval allowed to elapse before the operation is performed.

Positions of patient and surgeon.—Some surgeons prefer the patient sitting in a chair, as being the position in which examinations are generally conducted. Others make the patient lie on a table with the head raised. Both have disadvantages, and it seems better to learn to operate with the patient lying on the right side. In this position blood passes into the side of the mouth and not into the larynx. The surgeon should sit on a low stool facing the patient. Those who have not employed this method are strongly urged to adopt it.

Either local or general **anæsthesia** may be chosen, or preferably a combination of these methods. Local anæsthesia means less bleeding and a more rapid operation.

If **plugging** with a local anæsthetic is employed, the strips of gauze should be tied together outside the nose to prevent them from being sucked into the larynx, and the patient must be told not to swallow the solution.

Preparation of the skin.—To prevent infection of the wound from the skin, the surface of the nose and the interior of both vestibules should be painted thoroughly with rectified spirit or with a 2 per cent. iodine solution. Long hairs inside the nose should have been removed.

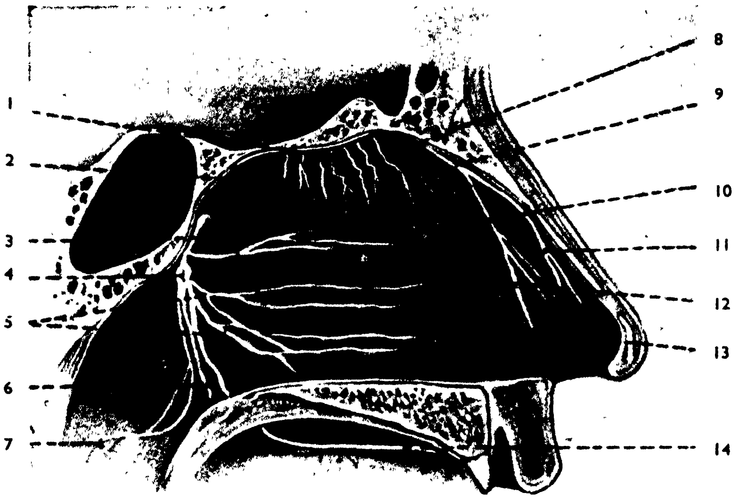


Fig. 667.—Lateral wall of nasal fossa.

1, Olfactory nerves ; 2, posterior ethmoidal artery ; 3, lateral posterior nasal branch of spheno-palatine artery ; 4, spheno-palatine ganglion ; 5, posterior superior lateral nasal nerves ; 6, 7, external and posterior palatine nerves to soft palate, uvula and tonsils ; 8, anterior ethmoidal artery ; 9, anterior ethmoidal nerve ; 10, internal nasal branch of anterior ethmoidal nerve ; 11, external nasal nerve (cutaneous) ; 12, posterior superior nasal nerve ; 13, lateral posterior nasal branch of spheno-palatine artery ; 14, anterior palatine nerve.

A towel or gauze should be brought over the mouth and fixed with clips to cover it completely.

Instruments.—Lamp, long speculum, scalpel, periosteal elevators, swivel-knife, cutting forceps, chisel and mallet, snare, needle, and dressing forceps. An aspirator for sucking out blood has great advantages, as the operation can be performed quickly and with less bruising than when constant sponging is employed.

Technique.—A single linear cut is sufficient, and may be made on either side of the septum. Some surgeons always incise on the same side, either right or left ; others choose the side of the convexity or where there is likely to be the most difficulty in separating the flap, especially when a sharp spur is present. The cut should be well forward on the septum, starting above, near the bridge under the fold of mucous membrane between the lateral cartilage and the septum. The incision passes straight down to the floor of the nose immediately in front of the thickened crest of the maxilla, which is nearly always seen just behind the vestibule. It is important to divide not only the mucous membrane but also the perichondrium, which is often adherent in this position. To start the separation of the perichondrium a small sharp elevator is employed, the tissue being stripped from the cartilage by careful dissection, without hurry. It is better to notch the cartilage than to damage the flap at this stage.

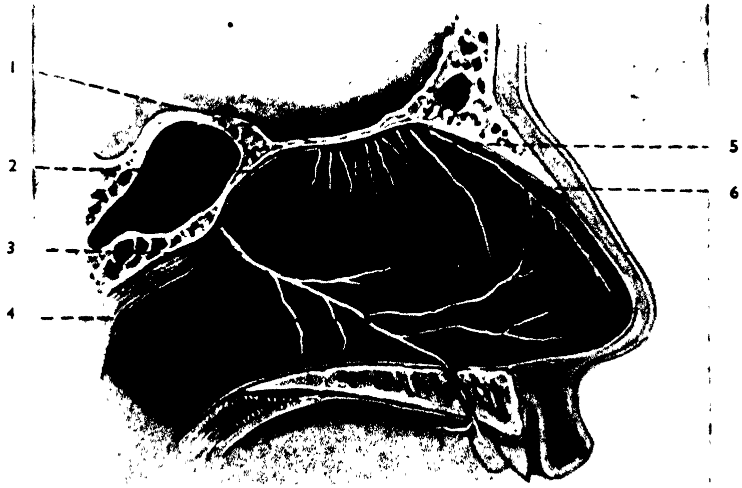


Fig. 668.—Septal vessels and nerves.

1. Olfactory nerves ; 2, posterior ethmoidal artery ; 3, spheno-palatine artery septal branch ; 4, naso-palatine nerve ; 5, anterior ethmoidal artery ; 6, medial nasal branch of anterior ethmoidal nerve.

Difficulty in separating the flap means that the perichondrium has not been completely divided. But when the separation is once started a large blunt elevator can be used and the dissection carried backwards, remembering to keep the edge of the elevator pressed firmly against the cartilage. When the latter is very prominent it may not be possible to elevate a long flap without danger of buttonholing, and if difficulty is experienced it is advisable to cut through the cartilage and to commence the dissection on its farther side.

This incision need not correspond with the original cut, but must be so placed that is passes anteriorly to the deflection. Great care must be taken not to perforate the mucosa lining the concavity, and if necessary the speculum can be introduced for a moment into the opposite nostril. With a blunt elevator it is generally easy to separate the flap far back on this side. The speculum is then introduced in such a manner that the two flaps lie outside its blades and the bare cartilage between them. With a small angular knife, or with Ballenger's swivel-knife, this can be removed in one piece. A cavity will then be seen between the flaps, and when the blood has been removed by suction or strips of gauze or small sponges of wool, the remaining septum must be examined in three situations: (1) High up under the bridge where further dissection is necessary to isolate the deflection. In this region cutting forceps should be employed, and care taken not to wrench away the cartilage, for fear of causing a depression of the bridge of the nose. (Fig. 669, B and C.) (2) The floor where the septum articulates with the crest of the maxilla. This part of the cartilage is tongue-shaped, and runs far back along the crest. In separating it the mucosa is easily torn. The wide bony crest can now be seen, and it is difficult to determine where its edges are situated, because the muco-periosteum is very adherent. A sharp elevator is necessary to separate the flaps from it. The cutting must be made directly inwards, because the upper part of the crest is much wider than the lower. The bone, having been isolated completely, can be removed with a small chisel or punch forceps. (Fig. 669, A.) To secure a successful airway, it is always necessary to remove this spur completely. (3) The septum must be examined farther back, as there is generally a prominence which must be removed. Lastly, the cavity is thoroughly dried again, and explored to make sure that no sharp pieces of bone or cartilage have been left. The speculum is withdrawn and the flaps placed in position again. The septum should now lie in a straight line from the bridge to the floor, and a plug of gauze should pass without resistance through each side of the nose into the naso-pharynx. If the operation is performed

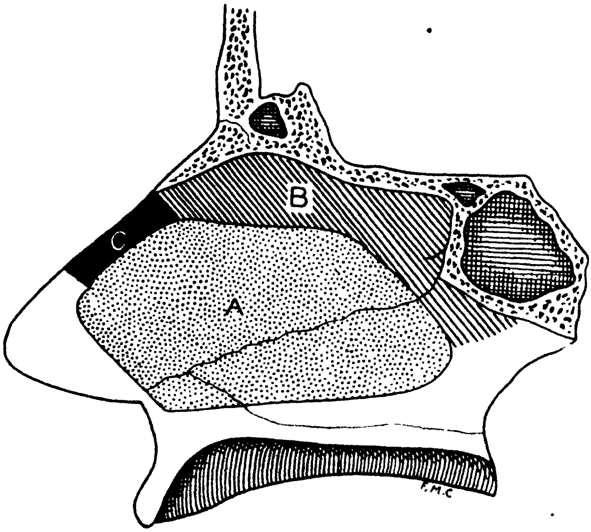


Fig. 669.—Resection of nasal septum.

A, cartilage; B, dangerous area; C, bridge of nose (injury likely to cause depression of bridge).

systematically and without haste, it is possible to avoid tears or buttonholing of the flaps ; to keep them in good position, it is advisable to unite the edges of the original incision with one or two horsehair sutures inserted with a hook-shaped needle.

To obtain a good result from this operation, attention must be paid to the following points :—

(1) *The whole of the obstruction must be removed,* not only the central portion of the septal cartilage. Unless the dissection is carried high up towards the bridge, well below the crest at the floor, and far back to the posterior nares, the flaps will not lie exactly in the middle line.

(2) *The flaps must not be torn.* Unfortunately, this accident is difficult to avoid when the membranes are thin. Large tears may result in a perforation of the septum, with crusting and obstruction afterwards. A small hole far forwards is to be feared, because a whistling sound may be produced with respiration and can only be cured either by a plastic operation or by enlargement of the perforation. A tear near the floor of the nose is not so serious as in other parts, and may even be beneficial, to prevent a collection of blood between the flaps.

(3) *Flapping of the septum.* After removal of a large part of the cartilage and bone it may be found that the septum is baggy and flaps with respiration. This condition may cause difficulty in breathing and great discomfort. In such cases it is advisable to replace some of the cartilage, using one large or several small pieces, between the flaps before the incision is sutured. If care is taken to prevent sepsis the cartilage rarely necroses.

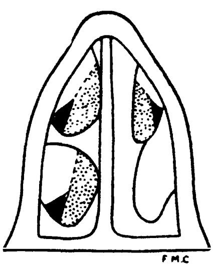


Fig. 670.—Trimming of turbinate bones. Portion to be removed is shaded.

(4) After the septum has been straightened *the turbinate bones must always be systematically examined.* On the side of the nose which was originally concave the inferior turbinate is generally enlarged, and the septum in its new position often lies in contact with it, so that the airway is blocked. To remove this obstruction the mucosa covering the anterior end of the turbinate must be trimmed away freely. Even in slight enlargements it is important to scar the surface and so cause the turbinate to shrink. The inferior turbinate on the convex side is flattened and may be so near the outer wall of the nose that the entrance to the inferior meatus is a slit through which air cannot possibly pass. To correct this deformity a small portion of the anterior end of the bone and its covering must be taken away. The removal of the posterior ends may also be necessary in certain cases, but it is important never to remove the inferior turbinates more freely than necessary, as this may result in troublesome dryness and crusting. (Fig. 670.) Nasal polypi, if present, can also be removed.

The middle turbinates are often unhealthy owing to old-standing ethmoiditis. In the hollow side of the nose the bone is frequently cystic and lies against both the septum and the ethmoidal cells. Such a condition leads to reflex headaches and prevents ventilation of the upper and middle meatus, with its consequences. The opposite turbinate is probably a thin shell of bone pressed firmly against the outer wall of the nose, from which it should be either removed or dislocated, so as to leave a free passage into the middle meatus. The anterior ends of the middle turbinates can be amputated without fear whenever they are inflamed or are causing any obstruction in the upper part of the nose. Those surgeons who boast that they never take more than ten minutes to complete a submucous resection cannot have realized the importance of the treatment of the turbinates.

(5) *Drainage of the sinuses may be necessary.* In cases complicated by sinusitis, drainage may be necessary to cure the catarrh. The question arises whether it is better to treat the accessory sinuses at the same operation or later, and it is impossible to lay down very definite rules on this point. In general, the wounded septum heals well, even when there is pus in the sinuses, but surgeons will be well advised not to attempt too much at one sitting, for fear of sepsis. Light curetting of the ethmoidal cells may, however, be considered, and if the antrum is affected a small opening can be made into it under the inferior turbinate, so that it can be washed out regularly and kept free from pus.

Plugging the nose.—The use of plugs after this operation is generally advisable, for prevention both of epistaxis and of hæmatoma between the flaps. The latter is more important, as, when the nose is not plugged, blood nearly always collects to some extent between the flaps, causing the septum to be unduly thickened, a condition which prevents the patient from breathing through the nose for many days. The danger of sepsis is also increased. Many forms of plug have been suggested. Hollow tubes offer certain advantages, but if rigid enough to allow the patient to breathe through them they are likely to cause neuralgia and headache, so are badly tolerated. Strips of gauze soaked in liquid paraffin containing oxychloride of bismuth, 20 per cent., are effective for keeping the flaps accurately in place, the oil preventing the gauze from becoming adherent. Another method is to insert into the nasal fossæ two rubber glove-fingers which have been lightly filled with wool, so that they are large enough to block the cavities completely. These plugs should be united by a strip of rubber to prevent their being sucked into the larynx, and they should be retained in position by a thin piece of adhesive strapping which grips the sides of the nose. The strapping should not be applied across the bridge of the nose, lest it cause a depression. The plugs can be easily removed after twenty-four hours, unless bleeding persists. As a rule, no further after-treatment is required, but care should be taken to remove any sloughs and to prevent the formation of adhesions. This can be effected either by passing a small swab of wool through the nose daily or by gentle syringing with normal saline solution if the mucus is excessive. Constant applications of liquid paraffin, either by spraying or with wool, are valuable, and prevent inflammation.

Results.—Submucous resection of the septum, if properly carried out, gives such excellent results that all other operations have been discarded. The patient can breathe freely through both sides, and can ventilate all parts of the nasal fossæ. The operation causes no external deformity, but on the contrary tends to improve the appearance of the nose by correcting the lateral displacement. The mucosa remains intact, the wound is small, and heals rapidly without crusting. Hæmorrhage is rarely severe. Serious inflammation is not to be feared, although in rare instances there may be infection of the accessory sinuses, or of the ears. A few cases of meningitis have been reported, and one of my patients died suddenly on the second day, of pulmonary embolism. It is important, therefore, to avoid this operation in persons who are known to be suffering from other organic diseases.

The most difficult cases are those in which a previous operation has been badly performed and only part of the obstruction has been removed. In these there may be great trouble in separating the flaps in the region that has previously been treated. The operation can only be performed well by those who have frequent practice, and is essentially one for the specialist.

OPERATIONS ON THE TURBINATE BONES

THE INFERIOR TURBINATE

The inferior turbinate bone is often enlarged in cases of rhinitis, and in the form known as hypertrophic rhinitis its mucous membrane may be so swollen that its surface has a cauliflower-like appearance. Such enlargements cause obstruction, and air can neither enter the inferior meatus nor pass between the turbinate and the septum. The same result is noticed with hypertrophy of the posterior ends. The slighter forms are generally treated by caustics such as pure chromic acid, by zinc ionization or by electro-cautery, used either to scar the surface or, better, to puncture down to the bone. The results of cauterization are not so permanent as those of operation.

Partial turbinectomy.—The redundant mucosa is trimmed with scissors or, if necessary, a cut is made through the bone near its attachment and the anterior part of it removed with a wire snare. The wire should be strong enough to cut through the bone cleanly. To prevent the persistent bleeding that sometimes follows this operation, a firm plug of gauze moistened with liquid paraffin should be inserted and left *in situ* for twenty-four hours.

The posterior end is more difficult to remove on account of its position. When cocaine is used the membrane may shrink so much that it cannot be seized by a snare. If necessary, a groove should be made in the bone in front of the enlargement with an upward cutting saw and the loop inserted into it. With a general anæsthetic the first finger can be passed behind the palate and used as a guide for the snare. As a rule, no plugging is required.

The whole inferior turbinate should never be removed, as this results in a persistent crusting rhinitis.

THE MIDDLE TURBINATE

This bone can be amputated without fear, either when it is so enlarged, or so compressed between the septum and the ethmoidal region that it causes obstruction of the upper part of the nasal fossa. Such a condition prevents ventilation of the olfactory region, and leads to catarrh and infection of the fronto-ethmoidal cells. Amputation is undertaken to open up the ethmoidal region in patients suffering from ethmoiditis or polypi, to cure reflex nasal headache or vacuum headache produced by absorption of air from a blocked frontal cell, and to gain access to the posterior ethmoidal cells and sphenoid.

With cocaine and adrenalin there is less bleeding than with a general anæsthetic. Both outer and inner aspects of the bone must be carefully anæsthetized. A cut is then made through the bone with nasal scissors, either from before backwards or, if the nose is narrow, from below upwards, to make a groove in the free margin of the bone. The anterior end can be removed quickly with a snare introduced into the groove and with very little discomfort to the patient. It is rarely necessary to take away the whole of this turbinate, or to plug the nose afterwards, as bleeding is seldom severe.

OPERATIONS ON THE LACRYMAL SAC

Various operations have been suggested to restore the function of the lacrymal apparatus in patients suffering from epiphora or suppuration of the lacrymal sac. West and D. R. Paterson about 1908 were the first surgeons to drain the sac directly into the nose, claiming that more cases can be cured by this means than by extirpation of the sac through an external incision. Although excellent results have been obtained with nasal drainage most ophthalmologists are still of opinion that there is no reason for allowing the rhinologists to take over the treatment of these cases. In skilled hands either method appears to give equally good results (*see* p. 1346).

When the trouble is due to suppuration in the anterior ethmoidal cells, drainage into the nose is undoubtedly the best method. Either general or local anæsthesia may be employed but a combination of both is preferable. Locally, the nasal mucosa should be shrunk with cocaine and adrenalin and the tissues in front of the middle turbinate bone with an injection of novocain, 1 per cent., and adrenalin, 1 in 1,000. By this means the bleeding can be largely controlled and the operation is rendered much easier.

INTRANASAL DACRYOCYSTOSTOMY (WEST'S OPERATION)

A small flap of muco-periosteum is turned back from the outer wall of the nose, with its base in front of the anterior end of the middle turbinate bone; as a rule, this flap is removed. The tip of the turbinate should be amputated when found to be enlarged. The area of bare bone thus exposed is removed with a chisel, a window being formed between the nasal fossa and the orbit. The opening is made sufficiently large to expose the inner wall of the lacrymal sac, and when necessary the anterior ethmoidal cell is cut away.

To control the bleeding which prevents a view of the sac at this stage, firm pressure should be employed for a few minutes. A probe is passed through the punctum in the lower eyelid and the sac is pressed through the window into the nose, so that its nasal wall can be seized with a tenaculum, drawn down, and freely excised. As bleeding is often persistent, this may be a troublesome undertaking, and in most cases it will be easier and better to open the sac freely by cauterization. The probe is removed and the sac is washed out with a lacrymal syringe introduced through the punctum. This treatment affords good drainage to the sac, and forty-eight hours later all suppuration has usually ceased. In old-standing cases where the sac has become fibrous there is a tendency for the fistula to close, but this can be prevented by occasional passage of a probe or, better, by insertion of a malleable lead style, which should be worn for 14 days. No plugging is necessary and the wound usually heals within a week.

EXTERNAL DACRYOCYST-RHINOSTOMY (TOTI'S OPERATION)

This procedure is preferred by some surgeons because of the certainty with which the lacrymal sac may be identified and the ease with which affected ethmoidal cells may be exenterated. Under local or general anæsthesia a small incision is made, beginning just above and internal to the inner canthus and carried downwards and outwards. By careful dissection, the orbicularis muscle is identified and divided, thus exposing the anterior lacrymal crest. Division of the deep fascia just behind the crest will expose the sac lying in the lacrymal fossa. The sac should be carefully freed from its bed and the lacrymal duct divided as low down as possible. The lacrymal bone is then perforated and any underlying sepsis in the ethmoidal system dealt with.

Before opening the cells a flap of mucous membrane should be made in the nose with its base forwards, as in the West operation, and employed afterwards to epithelialize the raw surface. An adequate opening is made into the nose and the nasal aspect of the sac is slit up with fine-pointed scissors from below upwards for about a third of its length. The cut margins are everted and anchored with a fine catgut suture. Lastly, the flap of mucous membrane is sutured to the anterior edge of the cut sac.

After-treatment consists in keeping the nose free from crusting until healing is completed, the catgut suture usually coming away on the 5th or 6th day. The sac should also be irrigated through into the nose with a lacrymal syringe until all suppuration has ceased. The cosmetic results are excellent.

Results.—The results obtained with these operations have been very satisfactory. J. S. Fraser reported (1929) 107 West operations; 89 were traced and of these 67 (75 per cent.) were reported as completely successful, the epiphora and suppuration having been cured. Holt Diggle also reported (1931) 79 West operations, of which 63 were traced ; 48 (73 per cent.) were completely successful, 6 improved but with some epiphora, and 14 were failures. Toti's reports of successful cases were also very good and rose rapidly from 60 to 80 per cent. As a general rule the most successful results are obtained in patients with large suppurating sacs.

Epiphora alone is more difficult to cure, especially if the canaliculus has been previously slit or enlarged or is not in contact with the ocular conjunctiva. Even with this complication, normal conveyance of the tears may result. Also, when there is no infection in the sac the nasal opening is very apt to heal again. In some instances it may be necessary to apply cocaine and enlarge the opening into the sac with a cautery more than once. If this is done properly, the percentage of cures may be even higher.

OPERATIONS ON THE ACCESSORY NASAL SINUSES

ANTRUM OF HIGHMORE

The maxillary antrum may require exploration for acute inflammation due to infection from the nose or from the teeth ; chronic sinusitis with or without suppuration ; necrosis ; foreign bodies ; polypi ; some cases of asthma and migraine ; or neoplasms, either simple or malignant. Bedford Russell* and others have shown that toxæmia may be caused by bacterial infections producing œdema of the mucosa and osteitis without any obvious discharge.

In all cases the condition of the teeth should be ascertained (if necessary by X-rays) and, if septic roots are discovered, the infected molars or premolars should be removed before an operation is undertaken. Equally important is the nature of the infection, and cultures should always be made, as the prognosis depends upon it. In many instances other sinuses also are infected, and drainage of the antrum is merely the first stage in treatment.

Exploratory irrigation.—If an infection is suspected, irrigation should always be employed first and for preference during an attack, because the inflammation may be intermittent and a negative wash-out may be obtained in the intervals. If necessary, X-rays should also be taken at different stages. Even when transillumination or X-ray shows that the antrum is apparently clear it may be full of purulent discharge, or the wash-out may appear to be fairly clear and yet if examined bacteriologically prove to be heavily infected. Blood intimately mixed with thin purulent discharge is usually caused by a severe hæmolytic infection—streptococcal or staphylococcal. Such infections cause great congestion of the lining membranes and may be very difficult to cure. When blood alone is washed out, the possibility of malignant disease should be considered.

In certain instances the normal ostium can be canalized if the middle meatus has been anæsthetized. Usually this is not possible and cocaine should be applied to the inferior meatus. With a fine trocar and cannula the antrum is punctured high up under the anterior third of the inferior turbinate where the nasal wall is much thinner than at the floor of the nose. Either a straight Lichtwitz needle or a curved Myles's trocar can be employed, care being taken that the point of the cannula is well in the cavity. If the cavity is not entered, air or lotion may be forced into the soft tissues and emphysema result, in which case the examination should be abandoned. The antrum should not be punctured above the inferior turbinate because the needle may pass into the orbit and infect it. When the lotion is forced through the cannula, mucus or pus is blown out through the normal ostium. If this is closed by inflammation the patient experiences a feeling of pressure and pain in the cheek and the discharge can only be removed by pumping the lotion in and out of the cavity through the cannula.

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* *Proc. Roy. Soc. Med.* (Sect. of Laryngol.), Jan. 1938, xxxi, 226.

Acute inflammation of recent origin can generally be cured by repeated lavage in this way but chronic infections usually require some form of permanent drainage.

Alveolar drainage.—This method is rarely employed except by dentists, and the younger generation of surgeons has almost forgotten that it exists. Actually, it is a very good operation, particularly for old and delicate patients, and it enables them to use an antiseptic mouth-wash and blow it through into the nose as often as necessary. Many patients find this less irksome than passing a cannula and washing out the antrum through the nose. The operation is free from risk and causes no shock. The only real objection is that the patient may be compelled to wash out the antrum daily for the rest of his life.

Either local or general anæsthesia may be employed. When a septic molar is present it should be removed ; if no molars are present an opening is made through the alveolus into the antrum. For convenience, this should be in the position of the first molar and the new canal should pass vertically so that a plug of rubber can be attached to a dental plate and inserted easily by the patient.

In Desault's operation, when the teeth are intact, the opening is made through the canine fossa above the teeth and kept open by a small metal plug. In either case the plug must be worn permanently.

The results are often satisfactory. The inflammation quickly subsides and the patient rarely complains of any discomfort or general debility.

Intra-nasal drainage.—The great majority of cases suffering from chronic suppuration can be cured by simple drainage of the antrum into the nose. Under cocaine or gas and oxygen a small opening can be made with a Myles's punch under the inferior turbinate bone into the anterior part of the antrum. (Fig. 671.) Through this opening a curved cannula is passed daily for purposes of lavage. To obtain a cure by this means it is essential to restore the normal opening of the antrum ; the discharge in it can then be easily expelled, and air can circulate freely through the cavity. When the normal ostium remains blocked, the anterior part of the middle turbinate must be removed, and the opening into the middle meatus enlarged. A lotion consisting of bicarbonate of soda and normal saline (1 dr. to 1 pint) is generally employed for lavage, but in obstinate cases peroxide of hydrogen, flavine (1 : 1,000), or ionization with iodine or zinc-sulphate solution may be necessary. If lavage is going to succeed, the character of the discharge begins to change within ten days. This failing, it is advisable to enlarge the opening under the inferior turbinate so that the cavity of the antrum is thrown freely open into the nose. If necessary, the linings of the antrum can be curetted through this opening and redundant mucosa or polypi removed.

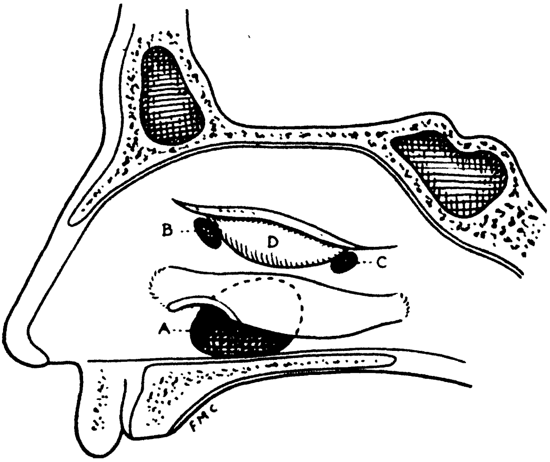

Fig. 671.—Intranasal drainage of antrum.
A, site of new opening ; B, opening of frontal duct ; C, antral ostium ; D, ethmoidal bulla.

In many instances a small part of the anterior end of the inferior turbinate must be amputated to allow free access to the inferior meatus. Free removal of the turbinate is deprecated because of the persistent crusting which may supervene. The best results are obtained by securing two small openings, near the roof and the floor of the antrum, rather than a single large hole under the turbinate. Given careful after-treatment, quite 80 per cent. of the chronic suppurations can be cured by this method. Failure to cure the discharge is often due to infection from other sinuses, such as the fronto-ethmoidal and sphenoidal cells.

Radical operations.—These should be reserved for cases which cannot be cured by intranasal drainage, for removal of foreign bodies, and for suspected malignant disease. They are more serious undertakings than the intranasal methods and should never be entered upon lightly or without proper consideration of the general condition.

It is unwise to promise a complete cure in any old-standing infection of the sinuses.

For most patients a general anæsthetic is to be preferred. Whenever possible an intra-tracheal tube should be used and the pharynx carefully packed. Otherwise the patient must lie on his side, because it is absolutely essential that no blood or pus should be allowed to pass into the lungs where it may set up bronchitis and broncho-pneumonia, which, unfortunately, are not uncommon after radical sinus operations.

Caldwell-Luc operation.—The nose is packed half an hour previously with ribbon gauze moistened with cocaine, 10 per cent., and adrenalin, 1 in 1000, and the gum and the soft tissues of the cheek over the canine fossa are infiltrated with several drachms of 1 per cent. novocain solution containing 10 minims of adrenalin, 1 in 1000, to the ounce. The cheek is retracted, and an incision is made in the gingivo-labial fold extending from the first molar to the lateral incisor tooth. The periosteum is elevated upwards until the infra-orbital nerve is identified as it emerges from its foramen. It is important to see this nerve clearly, in order to avoid damage to it during the course of the operation, for failure to observe this precaution may lead to troublesome post-operative neuralgia. The wall of the antrum is next opened in the canine fossa with a gouge and mallet, the opening then being enlarged to the desired extent with cutting forceps. Care must be taken not to remove bone too freely in a downward direction, in order not to interfere with the vitality of the teeth, but the opening may with advantage be carried well inwards towards the pyriform angle and well upwards between the infra-orbital foramen and the ascending process of the maxilla, in order to secure adequate exposure of the antro-nasal wall. Should there be troublesome bleeding at this stage, the antral cavity may be plugged for a few minutes with gauze soaked in peroxide of hydrogen or adrenalin, thus enabling the surgeon to inspect the mucous membrane and to perform further manipulations, such as the removal of polypi, of foreign bodies or of a piece of growth for microscopic section. In many cases the next step will be to remove the diseased mucous membrane lining the antrum, as it has been shown that a fresh lining of ciliated epithelium will regenerate.* The cut edge of the mucous membrane is elevated from the bone and further separation is secured by small gauze mops, until completed. The cavity is dried and any further tags of mucous membrane are removed.

Free drainage into the nose is next established by removing the bony wall of the inferior meatus with a chisel, carefully preserving intact the muco-periosteum of the antral wall. The opening in the bone is enlarged well forwards and downwards so that the floor of the two cavities is as nearly level as possible. A flap of mucous membrane is turned down from the meatus into the antrum, as described by Bönninghaus, thus helping to epithelialize the cavity. In many instances the inferior turbinate has already been trimmed and an opening made beneath it at a previous operation. In this case the communication is enlarged by cutting away the partition until level with the floor of the nose: The original incision in the mouth can be closed with several catgut sutures to promote rapid healing and to avoid infection from the mouth. Although most surgeons prefer not to plug, a good result can often be obtained by inserting through the nose and into the antrum a strip of gauze smeared with Bipp.

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* C. D. Knowlton and G. W. McGregor, *Arch. Oto-laryngol.*, Dec. 1928, viii, 647.

Several modifications of this operation have been advised, of which the most widely practised is that of **Denker.** He carries the opening of the antrum forward into the nose to obliterate the recess which is left in the front of the antrum by the Caldwell-Luc operation. Anæsthesia of the teeth is more likely to follow this approach.

The *after-treatment* of these cases is similar to that of simple intranasal drainage, but healing may be delayed for two or three weeks and it may be necessary for the patient to wash out the cavity for even longer.

With radical operations good results can be obtained, and *complications* are rare. The danger of osteomyelitis and of meningitis, though slight, must be remembered, especially in cases complicated by multiple sinusitis.

ETHMOIDAL CELLS

These cells are a complicated gallery of air-spaces in the lateral mass of the ethmoid, communicating with the middle meatus of the nose. Infections of the nose are frequently complicated by inflammation in these cells, and operations are often necessary for acute suppuration with high temperature and persistent pain ; for chronic infections causing persistent discharge and obstruction, often associated with sinusitis of the antrum ; and for nasal polypi.

The following methods of treatment are employed :—

Removal of the middle turbinate bone.—This operation is often the first treatment required. Amputation of the anterior portion of an enlarged middle turbinate opens the upper part of the nasal fossa and thereby affords drainage to distended ethmoidal cells. It also exposes the infundibulum, and makes it possible in some cases to wash out the frontal sinus with a cannula. Most cases of acute suppuration in this region can be relieved by partial turbinectomy.

Removal of polypi.—Mucous polypi grow from the muco-periosteum of the ethmoid and are attached either to the middle turbinate bone or to the lining of the ethmoidal cells. In their simple forms the polypi are pedunculated, and can best be removed by a wire snare. The loop is passed around the polypi as high up as possible, tightened, and used to tear them out with their bases of attachment. By this means the attached portion of the middle turbinate is generally removed. When the polypi are very numerous they can be avulsed with nasal forceps more quickly than with a snare. With a curette or spoon, the ethmoidal cells can be opened up and cleared of swollen mucosa and polypi. In this operation great care should be observed to keep the cutting edge of the ring knife against the outer wall of the nose, so that the cribriform plate may not be injured. The pressure must be strong enough to break down the partitions between the cells, but the curette must not be thrust against their outer walls, for fear of breaking through into the orbit. To obtain a good result, it is important to search diligently for concealed cells, especially those which are situated far forwards near the infundibulum and posteriorly in the region of the sphenoid. Hæmorrhage may be severe but generally ceases shortly after the operation, without plugging.

The ethmoidal region must be regarded as a dangerous area, where operations should be performed carefully, and only by those with experience of intranasal manipulations. The complication to be feared is meningitis. Considering the number of cases of ethmoiditis that are treated, it is surprising that the meninges are so rarely infected, but it must be remembered that fatal results have followed even the simple operation of turbinectomy. Fracture into the orbit should always be avoided, an accident recognized by the resulting emphysema and hæmorrhage into the eyelids. In one of my patients an orbital abscess developed after curettage.

Exenteration of the ethmoidal cells.—If the ethmoidal cells were confined to that part of the bone which lies between the nasal fossa and the inner wall of the orbit, it would be possible to obliterate all the cavities by intranasal operations. Unfortunately, there are often prolongations extending across the roof of the orbit, reaching sometimes as far as the external process of the frontal bone. In these deep recesses suppuration and catarrhal inflammations are often persistent, and relief can only be obtained by an external operation. For complete exenteration of the ethmoidal cells the skin over the area of operation is injected with novocain-adrenalin solution and the nasal fossa packed with ribbon gauze soaked in cocaine and adrenalin. A curved semilunar incision is made through the skin, commencing at the inner third of the lower margin of the eyebrow and extending around the inner wall of the orbit to a point below the lacrymal groove. The incision is carried down to the bone through the periosteum, and cuts the anterior ethmoidal vessels, which should be ligatured and divided close to their exit from the bone. With an elevator the periosteum is separated from the inner wall of the orbit, and a retractor is introduced to draw outwards the eyeball and its coverings. With a chisel or punch forceps the ethmoidal gallery is opened up and the whole lateral mass is removed as far back as the posterior nares. The prolongations into the roof of the orbit are traced to their ends and opened up, so that the lining membranes can be removed. Care should be taken to avoid injury to the cribriform plate. The middle turbinate should be excised to open up the upper part of the nasal passage. The whole cavity should then be smeared with a small amount of Bipp, and the external wound closed with sutures. Healing is rapid after this operation, and such good results can be obtained that the surgeon need not hesitate to carry out the treatment if intranasal surgery has failed.

TRANSANTRAL OPERATION ON ETHMOIDAL AND SPHENOIDAL SINUSES

Indications.—Multiple sinusitis involving the antrum, the ethmoids and sphenoids in certain cases where intranasal surgery has failed to give adequate relief.

Technique.—The preparation of the patient and the preliminary steps are as for the radical antrum operation (*see* p. 1894). The mucous membrane having been removed from within the antral cavity, the ethmoidal system is opened through the postero-superior angle of the antrum by punch-forceps, entering the posterior ethmoidal group of cells. These can now be exenterated backwards to the sphenoid, inwards to the attachment of the middle turbinate bone, if still present, forwards through the anterior group to the frontal angle, and downwards to the attachment of the inferior turbinate. The removal is effected by punch-forceps and curettes. The anterior wall of the sphenoidal sinuses having been exposed, the ostium may be enlarged under vision to the required degree by means of upward- and downward-biting punch-forceps; great care must be taken in removing the upper part of the front wall to avoid injury to the floor of the anterior cranial fossa. Bleeding may be encountered from the septal branch of the spheno-palatine artery where it crosses the floor of the sphenoidal sinus. Some surgeons advocate ligaturing this vessel to obtain hæmostasis, but it can in nearly all cases be adequately controlled by firm pressure. The middle turbinate bone is next removed, by means of nasal scissors and a snare, to complete the ethmoidectomy. (Fig. 672.)

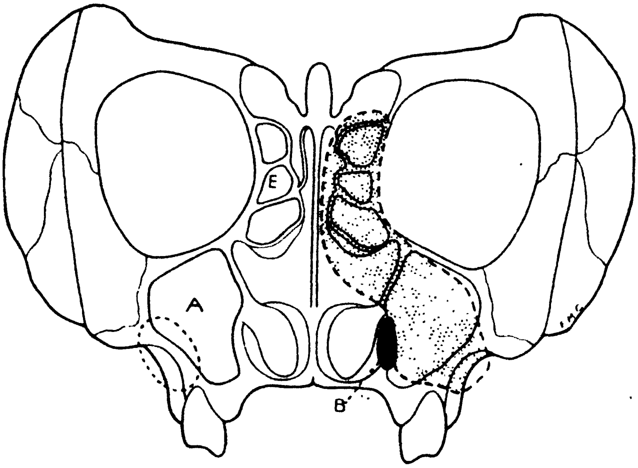

Fig. 672.—Transantral removal of ethmoidal sinuses.

A, opening in canine fossa. B, opening below inferior turbinate bone. Area to be removed shaded.

Some surgeons, notably J. B. Horgan,* advocate that the middle turbinate should be spared whenever possible, in order to preserve its valuable physiological properties of moistening, warming and controlling the air current. In cases which merit an extensive procedure of this nature, however, it is uncommon to find a middle turbinate which has not been affected by polypoid changes.

The operation is completed by creating an opening beneath the inferior turbinate and suturing the alveolar incision. No plugging is necessary, nor as a rule desirable.

Bedford Russell, on the other hand, advocated removal both of the middle and inferior turbinates so that the nasal passage, ethmoidal area and antrum are converted into one large cavity (cavitation operation). In his experience this does not cause crusting, although this may occur in cases in which a skin-graft has been used. With this method bleeding may be severe but can usually be controlled by firm pressure with swabs or with strong peroxide of hydrogen. Recurrent hæmorrhage also is rare. In those cases in which there is bleeding there is usually infection with hæmolytic organisms, and sulphonamide is given to counteract it.

The **after-treatment** consists in saline irrigations for a short time to remove adherent clots or crusts. Persistent crusting is not a troublesome complication, in spite of the very free removal of tissue, but when it does occur it is, as a rule, due to incomplete drainage of infected ethmoidal cells.

FRONTAL SINUS

The treatment of infections of this sinus still presents great difficulties, and much controversy exists as to the best method of obtaining relief. Operations should only be undertaken after careful examinations, and in all cases X-ray photographs are essential.

Intranasal drainage.—This method should be chosen whenever possible. The middle turbinate bone is often enlarged and pressed against the outer nasal wall, thereby blocking the anterior ethmoidal cells, which become distended with secretion and polypi. Usually the first treatment is removal of this obstruction; a cut is made from below through the middle turbinate to its base of attachment, selecting a point about the middle of the bone, and the anterior end is then amputated with a wire snare. The anterior ethmoidal cells, if distended, should also be broken open; after the infundibulum is exposed in this way it is often possible to pass a cannula and wash out the frontal sinus.

When a passage cannot be discovered easily it is not advisable to force one; it is safer to wait until the swelling subsides. With improved drainage the inflammation in the sinuses may subside or, if the discharge persists, a further attempt may be made to pass a cannula. With careful after-treatment similar to that described for the antrum (p. 1398) the majority of acute infections can be relieved. But when no passage to the sinus can be found, an attempt should be made to dilate the infundibulum. To force an instrument from the nose is exceedingly dangerous, and if a burr is used to enlarge the bony canal a traumatic stricture invariably results, and must be constantly dilated. To obviate this difficulty, an extranasal method of permanently enlarging the infundibulum has been devised.

Extranasal operations.—**Indications.**—Acute sinusitis with severe toxæmia when complications are feared ; persistent discharge which cannot be relieved by intranasal treatment ; chronic purulent sinusitis causing fever, persistent headache, pain, toxæmia and nerve exhaustion ; recurrent polypi, constriction of frontal duct causing " vacuum headache " ; mucocele ; external fistula or necrosis ; sinusitis with intracranial complications ; tumours of the fronto-ethmoidal region.

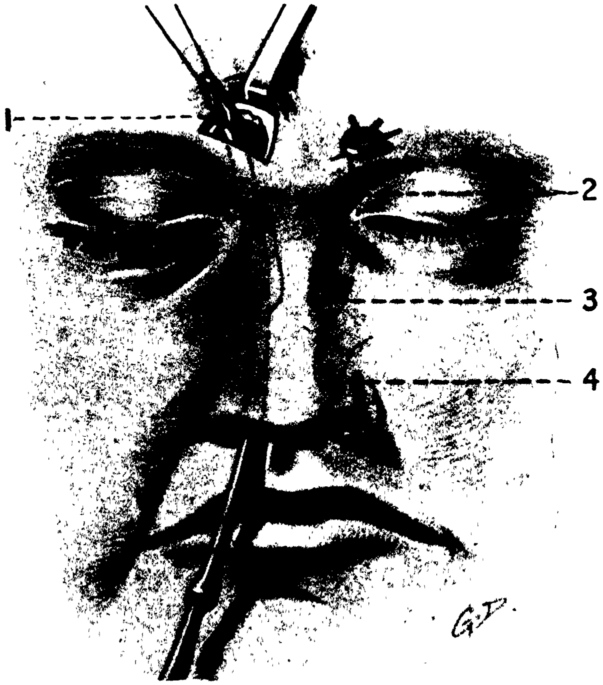

Fig. 673.—Intubation of frontal sinus.

1, Catheter drawn through sinus ; 2, short tube in frontal duct ; 3, middle turbinate ; 4, inferior turbinate.

Intubation of frontal sinus.*—(Fig. 673.) This method can safely be employed for most of the conditions specified above and is particularly suitable for very acute types of inflammation. Even chronic infections may subside with prolonged intubation.

The intranasal tissues are thoroughly shrunk by plugging the nose on the affected side with a strip of gauze moistened with cocaine-and-adrenalin solution. The eyebrow and forehead are treated with iodine or spirit but are not shaved, as the hairs in this region grow very slowly. To prevent troublesome bleeding, an injection of novocain-adrenalin solution should be made into the tissues over the frontal sinus. An incision ¾ in. long is made below the inner end of the eyebrow, dividing all the tissues down to the bone. Care should be taken not to expose or divide the supra-orbital nerve for fear that it may afterwards become involved in scar tissue and cause persistent discomfort or neuralgia. The periosteum is retracted upwards, and the whole wound is thoroughly treated with Bipp. An opening ½ in. long is made into the frontal sinus above the supra-orbital margin, the bone being first perforated by gentle chiselling and the opening then enlarged by a burr or bone-forceps. The centre of this opening should lie ⅜ in. from the middle line, as this point is usually directly above the upper opening of the infundibulum. The mucosa is then divided, and secretion removed from the sinus. A fine malleable probe is passed through the infundibulum into the nose, and its lower end is seized and brought outside the anterior nares. A stout linen thread having been tied to its lower end, the probe is withdrawn, and the upper part of the thread drawn through the nose out of the wound on the forehead.

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* Harmer and Russell, *Journ. Laryng. Otol.*, June, 1931, xlvi, 384.

At this stage, or earlier, it is advisable to remove the anterior portion of the middle turbinate bone and to open up the anterior ethmoidal cells. A soft rubber tube is then attached to the lower end of the thread, by means of which it is drawn through the infundibulum and out of the frontal sinus. It is essential that the tube should be small enough to pass through the duct without damage to its lining, and when the bony canal is very contracted there may be some difficulty both in passing the probe and in introducing more than a very small tube. The tip of the catheter is cut off and a small piece attached transversely so as to anchor it to the forehead and prevent it slipping down into the nose. (Fig. 673.) The external wound should again be Bipped, but not closed by sutures as it is important to provide free drainage above and below in the early stages of the treatment ; otherwise the wound may become inflamed, swollen and painful, and recovery may be delayed. A very light dressing is needed. The operation can usually be completed in fifteen minutes, and causes so little shock that the patient can leave bed in a day or two.

After-treatment.—In acute cases a cannula should be passed into the tube and the wound gently irrigated with warm saline solution or peroxide of hydrogen for ten to fourteen days. About this period the tube can sometimes be removed, but only when the external wound has healed and the discharge has completely ceased.

With chronic sinusitis it is necessary to intubate for long periods, generally for one to three months. After the first ten days a rather larger tube can usually be inserted and this should be repeated at regular intervals, the principle being the gradual dilatation by elastic pressure of the fronto-nasal duct without damage to its lining or discomfort to the patient. During the later stages the tube need only be drawn up so that its upper end is lying in the sinus, in which case it is anchored to the forehead by strings passed through and tied to a small circular rubber button. (Fig. 678.) With this method the wound gradually closes except at the point where the thread passes out on to the forehead. In many cases irrigation through the tube is only required for a week or two, but this should be continued as long as the discharge is copious. If the tube is not too large it causes no discomfort, and the patient can return to his work after a few days.

By this simple operation it is possible permanently to dilate the infundibulum. Bone absorption takes place around the tube; a straight canal is produced lined with unscarred epithelium which does not contract later after removal of the tube. Given careful after-treatment, the majority of cases of frontal sinusitis can be cured with very little disfigurement.

Results.*—A report of sixty-three patients treated by this method showed the following results: In 15 cases suffering from acute sinusitis, pain was permanently relieved in 12 and discharge in 10. One patient died of cerebral abscess. In 35 cases of chronic sinusitis, pain was relieved permanently in 16 and discharge in 19. The failures were due to insufficient after-treatment, involvement of other sinuses, faulty previous operations, and general debility. Two patients died, one of erysipelas two years after operation; the other committed suicide. In 5 cases suffering from pain due to obstruction of the frontal ducts (vacuum headaches) and in 8 cases of mucoceles, all obtained relief. The operation is a simple one and quite free from danger. It is far better than the Ogston-Luc operation where, after opening the sinus, a burr is used to dilate the infundibulum and a tube is inserted. With the latter the results were unsatisfactory because when the tube was removed the scarred tissues contracted and a fibrous stenosis resulted.

Radical operations.—These should be reserved for cases which cannot be relieved by simpler methods, or for sinusitis with intracranial complications and tumours. They should only be undertaken by specialists who have frequent opportunities of performing them.

External operation with removal of floor of sinus.—The operations most commonly practised are those described by Howarth in this country, and by Lynch, Sewall, Ferris Smith and others in America. The technique of these interventions, in which the frontal sinus is approached from the orbit with exposure of the ethmoidal system, differs only in detail from the procedure described by Jansen in 1894.

Anæsthesia may be either local or general. In the former, as practised by Ferris Smith and others in America, the nose is packed with ribbon-gauze soaked in cocaine-adrenalin mixture, and the skin is infiltrated with novocain-adrenalin solution around the inner canthus and supra-orbital region. Many operators in this country

* [illegible] June 1931, xlvi. 384.

prefer to combine these measures with a general anæsthetic, for the comfort of both the patient and the surgeon.

Technique.—The eyelids on the affected side are sutured to prevent injury to the eye. A small curved incision, three-quarters of an inch long, is made through the skin, beginning below and just internal to the supra-orbital notch and extending downwards a quarter of an inch mesial to the inner canthus. The superior palpebral vessels are ligatured and the incision is carried down to the bone. With a sharp elevator the orbital periosteum is stripped upwards to the roof of the orbit, downwards to the lower margin of the lacrymal fossa—this displaces the important structures, namely the pulley of attachment of the superior oblique muscle and the lacrymal sac—and backwards to the posterior ethmoidal vessels and nerve, the vessels being ligatured and divided close to their entrance into the bone. This is facilitated by a curved self-retaining retractor. The lacrymal fossa, the floor of the frontal sinus and the lamina papyracea of the ethmoid being exposed, the mesial orbital wall is perforated and bitten away with punch forceps, preserving if possible three-eighths of an inch of the lower margin. The posterior margin of the nasal process of the maxilla is removed with heavy punch forceps to permit free inspection of the anterior ethmoidal region. By means of forceps introduced through the nose, the ethmoidal cells are carefully removed, back to the sphenoid. The middle turbinate is gently levered outwards towards the orbital wall, and Grünwald punch-forceps are introduced with the female blade along the cribiform plate. The bone is punched clearly away without twisting or tearing. Any remaining ethmoidal cells are dealt with, and if the mucosa covering the nasal roof is diseased it can readily be stripped away by small gauze mops soaked in a solution of 5 per cent. picric acid in 85 per cent. acetone, as practised by Ferris Smith. The sphenoidal sinus is opened by introducing a Sluder knife in the ostium, which is enlarged sufficiently to admit punch-forceps. The whole anterior wall is removed, care being taken to keep the forceps parallel with the nasal roof when removing the upper margin in order to lessen the risk of damage to the floor of the anterior cranial fossa (Fig. 674). As much as possible of the bony sphenoidal floor is removed, avoiding (if possible) damage to the septal branch of the spheno-palatine artery which traverses the mucous membrane covering the nasal surface of the floor of the sphenoid. By elevating the mucous membrane it is possible to ligature this vessel before dividing it, but in most cases firm pressure with a swab will satisfactorily control the bleeding. If the mucosa of the sphenoidal cavity is polypoid, it can be gently removed by an elevator or teased out by small strips of gauze soaked in the picric acid solution. The floor of the frontal sinus is removed and the cavity inspected with the aid of a small mirror of the post-nasal type. Any polypi seen should be removed, but the rest of the mucous membrane should if possible be preserved intact. All fronto-ethmoidal cells are carefully followed up and opened. A rubber drainage tube is selected, sufficiently wide to fit snugly into the frontal sinus. One or two windows should be cut in the tube to assist drainage, and its length adjusted so that its lower end is just above the attachment of the inferior turbinate bone. A piece of oiled silk is then placed over the tube and its upper and lower ends are tucked under the cut edges of the bone. A small Thiersch graft cut from the arm or thigh is placed on the oiled silk with the raw surface outwards. The graft must be adjusted accurately, so that its upper and lower ends are tucked under the bony edges. An excess of graft extending backwards along the lamina papyracea is undesirable, since it may lead to excessive squamous epithelium formation and consequent post-operative crusting.

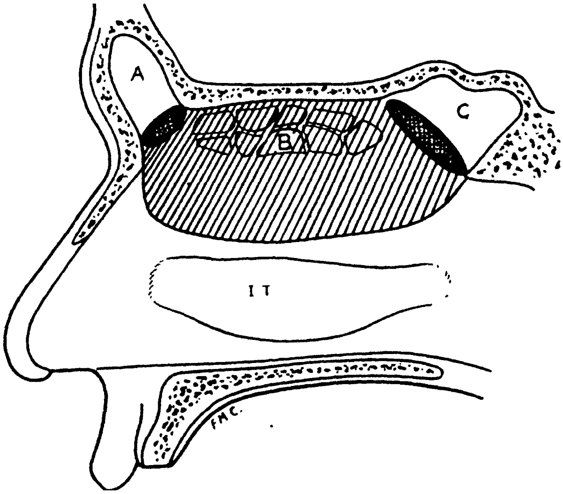

Fig. 674.—External operation for frontal sinus.

A, Opening into nose. B, Ethmoidal area to be removed, shaded. C, Opening into sphenoid. IT, Inferior turbinate.

The cut edges of the periosteum are approximated with fine interrupted catgut sutures to connect the soft parts with the graft. The skin incision is closed by vertical mattress sutures of horsehair, which are removed on the fourth day. The tube and oiled silk are removed on the tenth day, after which the patient may be allowed to get up. After-treatment consists of daily irrigation with normal saline until the cavity is clean.

Obliteration of the frontal sinus.—The indications for this operation are failure to relieve the patient by less radical measures or osteomyelitis of the frontal bone.

Technique.—A curved incision is made the full length of the eyebrow, extending down, internal to the inner canthus, to the side of the nose. The supra-orbital vessels are picked up and ligatured. The periosteum of the frontal wall is elevated upwards with the soft tissues, and the orbital periosteum is detached with the contents of the orbit until the floor of the sinus is exposed. The sinus is opened by means of a gouge, and the anterior wall, including the supra-orbital ridge and the floor, are completely removed with punch forceps. All shreds of mucous membrane are carefully detached from the inner wall of the sinus, which should be inspected for areas of infected bone or sequestra. Having bevelled off the cut margins of the sinus, the soft tissues are brought together and accurately sutured. A drain should be left in the lower part of the wound for several days. Firm pressure must be kept up over the flap of soft tissue in order to encourage adhesion between the skin-flap and the posterior osseous wall. The cosmetic results after the operation naturally vary with the size and shape of the infected sinus, but subsequent fat grafts can do much to improve the disfigurement. The functional results are very good.

Killian operation.—This has been extensively practised but is now mainly of historical interest. In approach it resembles the obliteration operation but differs in the preservation of a bridge of bone and periosteum along the supra-orbital ridge. It has fallen into disuse owing to the liability to postoperative sepsis, followed by necrosis of the bridge of bone and, in some cases, a spreading osteomyelitis.

Technique.—Two periosteal incisions are made : (i) From the outer part of the wound to the glabella just above the supra-orbital ridge ; the periosteum above this line is separated with an elevator and retracted upwards with the soft tissues. (ii) In the line of the skin incision but below the supra-orbital ridge, thus leaving a bridge of bone with its periosteal covering intact. The periosteum of the nasal process of the superior maxilla and of the inner wall and roof of the orbit is detached backwards and retracted downwards and outwards with the eyeball and its coverings. If possible, the attachment of the pulley of the superior oblique muscle to the orbit should be preserved.

With a chisel and mallet the frontal sinus is opened above the ridge, and the whole of the anterior wall removed with cutting forceps. The mucosa is incised and removed completely. The floor of the sinus is also cut away, together with the nasal process of the superior maxilla. The ethmoidal cells are exenterated completely, and a free communication established with the middle meatus of the nose. The middle turbinate must be cut away, unless this has already been done. If necessary, the sphenoidal cell can also be opened freely. The wound having been irrigated with peroxide of hydrogen and the bleeding arrested, a careful search must be made for deep pockets, especially along the roof of the orbit, and the overhanging edges removed. The septum between the frontal sinuses should be examined and, if a perforation is found, the sinus on the other side must be opened up. To complete the operation, an anchored tube should be inserted, and the wound lightly packed with Bipp gauze.

Usually the external wound should not be closed with sutures. The gauze should be removed two days later and, thereafter, the cavity irrigated daily until all discharge has ceased. In most cases the external wound heals rapidly and, owing to the preservation of the supra-orbital arch, with very little deformity. The operation is a serious undertaking and has a considerable mortality. It does not always give good results because there is often a dead space behind the bridge which becomes filled with granulations and later with scar tissue. Also there may be persistent discharge and faulty drainage owing to stenosis between the nose and sinus.

Complications of radical operations.—Radical operations on the frontal sinus are not free from danger. Logan Turner collected the records of 24 fatal cases, and many others have occurred.

Neuralgia.—This is fairly common and may be very serious. Sometimes the attacks of pain are so severe as to be intolerable. They may last for years and cause mental disturbances. For some unknown reason the depression may be out of all proportion to the local conditions. The general health may never be quite as good after radical operations. This may be due to involvement of the supra-orbital nerve in scar-tissue, with the formation of painful neuromas. These may be injected with 80 per cent. alcohol with complete relief of symptoms for long periods, but it is sometimes necessary to excise that portion of the nerve which has been caught up in the scar-tissue.

Retrobulbar neuritis.—This is rare and may result in loss of sight on the affected side.

Osteomyelitis of the frontal bone is a serious complication which may arise spontaneously in the course of an infection of the frontal sinus, usually of an acute type, or may follow external operations. The inflammation spreads upwards and outwards along the venous channels of the diploë, and at an early stage the skin of the forehead and eyelids becomes œdematous and tender, sometimes without any rise in temperature. A slight œdema is not serious, but when the puffiness is increasing or the bone is sensitive to pressure, no time should be lost before the wound is freely opened. In more extensive cases exposure is obtained by extending the incision outwards to the external angular process, upwards along the temporal crest to a point within the hair line, and from there parallel with the line of the hair right back to the middle line. The rectangular flap is turned inwards to give complete exposure of the affected frontal sinus and bone. If the infection in the diploë has crossed the middle line, the flap may be planned to turn downwards, thus exposing the whole of the frontal bone. In mild cases only the outer table and affected diploë are removed, but it is often advisable to remove the whole thickness of the bone down to the dura mater. The scalp flap is sutured back in place with drainage. Many successes have been reported in the treatment of this condition, notably by Von Eicken,* but where the condition is at all extensive the prognosis must be grave.

Orbital cellulitis or abscess may also require free drainage.

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* Proc. Roy. Soc. Med. (Sect. Laryng.) Nov. 1935, xxix, 192.

Meningitis may supervene without injury to the cranium, but is more often the result of a fracture of the posterior wall of the sinus or of the cribriform region. The greatest care must therefore be taken to protect these regions from injury. Bipp often prevents the spread of infection.

Abscess of the frontal lobe and subdural abscess may develop in any old-standing case of sinusitis with or without operation. Occasionally a radical operation on the frontal sinus fails to relieve the symptoms and a further operation becomes necessary. On opening up the wound again the pus may be found to come from a cavity inside the cranium (subdural abscess), and can only be cured by free drainage. Abscess of the frontal lobe, being in a silent area of the brain, may present difficulties in diagnosis, and is frequently overlooked until spreading cerebral œdema begins to involve the motor area. The abscess may be unilateral or bilateral. In one case after drainage of a small abscess in one frontal lobe there was no improvement and the patient died six weeks later. Post mortem, a much larger abscess was unexpectedly found in the opposite lobe. If the abscess becomes encapsuled it may be mistaken for a cerebral tumour. Complete recovery may follow successful drainage.

SPHENOIDAL SINUS

Indications.—Chronic suppuration, usually associated with infection of the posterior ethmoidal cells, and often responsible for persistent occipital headache and general toxæmia ; for the relief of certain cases of Eustachian catarrh and otorrhœa ; chronic pharyngitis (sore throats) ; in cases of retrobulbar neuritis caused by sphenoidal infection ; and as one method of exposing a tumour of the pituitary gland.

Operation.—The sphenoidal sinus is a cavity of variable size and shape. X-ray examination, particularly after partial filling with a contrast medium such as lipiodol, is a very important pre-operative measure because it shows whether the cavity is dense, owing to thickening of its mucosa or to discharge. Also it reveals any asymmetry, such as an extension across the middle line or laterally into the great wing of the sphenoid bone.

Exploratory puncture should always be made, before any operation is advised, to prove whether there is inflammation or not, and acute infections can usually be relieved by this treatment alone. The puncture should be made through the lower part of the anterior wall of the sinus and under no circumstance should force be used. In many instances a fine cannula can be passed through the normal ostium but, if there is difficulty, part of the middle turbinate bone may have to be removed to expose the front of the sphenoid sufficiently.

With Watson Williams's method the front of the sphenoid is well cocainized. The trocar and cannula are passed between the septum and the middle turbinate bone, and pushed through the bone with gentle pressure, care being taken not to injure the posterior wall of the cavity. If the bone is very hard, a spot rather farther forward can be tried, but those who have not much experience of operations on the sinuses must remember they are dealing with a dangerous region and that, after long-continued infection, the bones may become softened or brittle. The landmarks are, therefore, very important; if the puncture is made too high it may damage the base of the skull or even perforate the anterior cranial fossa. By this means the sinus can be washed out or aspirated and so the presence of discharge and the infecting organisms can be determined.

Chronic infections usually require an operation to provide permanent drainage. A local anæsthetic is generally preferable, as there is much less bleeding than with general anæsthetics and the operation can be performed safely and neatly. The greater part of the middle turbinate bone is removed to give free access to the sphenoidal region. A Sluder's knife is passed through the normal ostium, which is enlarged so that it will admit the blades of a Hajek punch forceps, and the anterior wall is cut away piecemeal, as low as the thick bone forming the floor of the sinus and laterally until the whole cavity is as freely opened as possible. The cavity can now be inspected. When normal the mucosa is pale and looks almost white but when infected it may be œdematous or highly injected and bleed readily when touched. Unless the tissue is polypoid the lining membrane need not be curetted and should not be removed, except anteriorly so that a very free opening is obtained.

The outer nasal wall should also be carefully examined and if an enlarged posterior ethmoidal cell containing pus can be found it should be laid freely open with suitable punch forceps.

Complications after this operation are rare, but instances of severe hæmorrhage, of basal meningitis, of injury to the optic nerve, and of thrombosis of the cavernous sinus have been reported.

The **after-treatment** consists in daily lavage, and in most cases suppuration ceases quickly. As St. Clair Thomson says, " the sphenoid is one of the most satisfactory sinuses to treat." But there are cases with heavy infection, particularly when complicated with multiple sinusitis or diffuse inflammation of the bones, when it may be difficult to prevent cicatricial closure of the opening. In these, prolonged treatment and further operations may be necessary.

REMOVAL OF NASAL TUMOURS: EXTERNAL OPERATIONS

Indications.—Innocent tumours (rare) such as papilloma, fibro-angioma, osteoma, and myxoma; many of these cases can be treated by endonasal methods. Malignant tumours are common, including carcinoma, either squamous or columnar-celled, sarcoma of all known varieties, and endothelioma. In the early stages they give rise to little trouble and, as symptoms are so indefinite, early diagnosis is generally impossible. In most cases the growths are more extensive than they appear to be, and they nearly always invade the neighbouring cavities —the antrum, the ethmoidal cells, the orbit or the mouth, and can only be completely removed by external operations. As they generally recur after cutting operations and are always very vascular, diathermy should always be used. A combination of surgery, diathermy and irradiation is now employed at many clinics, and gives much better results than surgery alone. If the tissue is completely coagulated before removal the whole operation may be rendered almost bloodless. Shock is less severe when the bleeding has been thus controlled. With surgery alone, ligature of the external carotid artery was often performed, but with diathermy this is rarely necessary except for serious secondary hæmorrhages which cannot be controlled by simple means. In these cases transfusions of blood may also be required. As malignant growths in these cavities rarely affect the glands, dissections of the neck are seldom necessary.

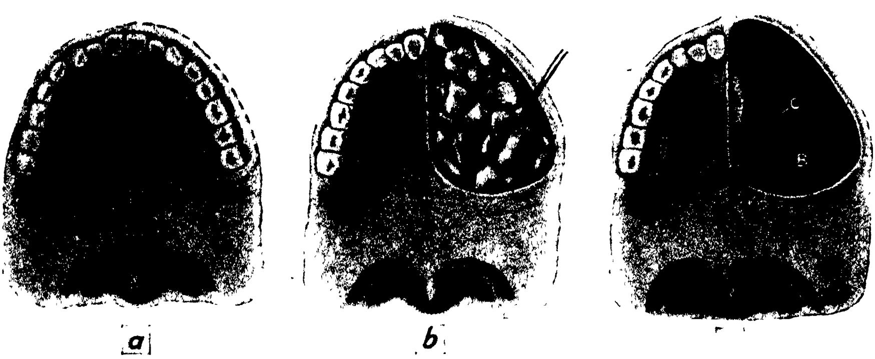

Fig. 675.—Transpalatal operation.

a, Incision. *b*, Exposure. *c*, Cavity after removal of growth.
A, Septum. B, Cavity. C, Opening into sphenoid. D, Posterior nares.

(1) **Transpalatal operation.**—A general anæsthetic should be given either through an intratracheal tube or after a preliminary laryngotomy, the pharynx being plugged to prevent blood passing into the lower air passages.

By removal of the hard palate, together with the teeth and alveolar process of the affected side of the jaw, the growth can be exposed from below. (Fig. 675.) Access can thus be obtained to a growth involving the antrum, the nasal fossæ and other sinuses. It can then be slowly coagulated by diathermy or excised by the cutting current. Usually, the whole inner wall of the antrum, together with the inferior and middle turbinate bones, should be removed ; afterwards the ethmoidal cells should be completely exenterated and the sphenoidal cavity widely opened. A large single cavity is thus obtained and the danger of recurrence is lessened. By this means all obvious disease can be removed but X-rays or radium or a combination of both may be employed to destroy outlying cells and to prevent recurrences. Preferably, a short course of deep X-rays should be given for a few days before the operation; after it, the cavity should be treated with radium, which may be inserted either at once, using a large tube containing 50 mg. of radium with a 2 mm. platinum filter wrapped in as much gauze as the cavity will accommodate and retained for 24 to 48 hours; or a number of radon seeds containing 1 or more mc. each (Quick's method) with threads attached for removal of the seeds later. On the other hand, smaller amounts of radium may be employed with advantage for long periods. After the removal of the growth the cavity is treated for about 10 days by frequent lavage, and rendered as aseptic as possible. Then a number of needles containing 0·5 to 1 mg. of radium are uniformly distributed on the surface of a dental plate, which is moulded to fill the whole cavity. Usually not more than 20 mg. are employed, for preference in needles with 0·6 to 0·8 mm. platinum filtration, as the thicker the filters the less the danger of necrosis. The patient wears this denture daily for about two hours night and morning, continuing the treatment until he has received a surface dose of 5,000 to 6,000 r., according to the amount of previous X-rays and to the reaction and filming produced in the cavity.

Naturally, severe reactions and some necrosis may follow such treatments but complications such as meningitis. osteomyelitis, general toxæmia and destruction of the eye are less likely than when large doses of radium are inserted into a septic cavity which has not been properly drained.

The transpalatal method has many advantages and should be employed whenever possible. It affords a good exposure of the growth, which can easily be destroyed by diathermy; it is easy to insert the radium in such a manner that the whole region obtains uniform radiation; the opening in the lower part of the cavity affords free drainage and good inspection so that at any time an early recurrence can be detected; the opening can easily be repaired by a suitable denture, which can be removed for cleaning the cavity; there is less tendency to crusting than with other methods; and as a rule there is no external deformity.

(2) **Lateral rhinotomy (Moure's operation).**—This operation (Fig. 676) is one of the best methods of gaining access to the nasal fossa from outside. The incision is made from the inner end of the eyebrow, along the side of the nose, around the lateral cartilage, and into the lower part of the vestibule. If a transverse incision is required it should pass along the eyebrow or through the conjunctiva of the lower eyelid rather than through the skin below it, as by this means œdema of the eyelid and disfigurement can be prevented. A flap of skin with muscles and periosteum is reflected from the front of the maxilla and drawn outwards with a retractor. The cartilaginous part of the nose is detached from the nasal bone and maxilla and retracted towards the opposite side. The periosteum is separated from the nasal bone and from the

ascending process of the maxilla. The lacrymal sac is displaced from its groove. A quadrilateral piece of bone composed of the nasal bone and part of the maxilla and lacrymal bone is then removed with a chisel or bone-forceps, and if necessary the opening is enlarged by cutting away freely the anterior wall of the antrum. The exposure that is now gained is to all practical purposes as good as that obtained by total resection of the jaw, and the extent of the growth can be accurately determined.

Whenever possible, a partial removal of the jaw should be undertaken, and with Moure's method the surgeon can determine whether it is necessary to sacrifice the orbital plate or the hard palate to eradicate the disease completely. The tumour must, however, be removed freely, so that only those parts of the bones are preserved which are obviously free from disease. In most instances the turbinate bones and the ethmoidal cells are completely exenterated. Hæmorrhage can usually be controlled by firm plugging for a few minutes. The cavity can then be plugged lightly with Bipp gauze with an end projecting from the nostril. The skin incisions are carefully united with sutures. Healing is rapid. The gauze should be removed in forty-eight hours.

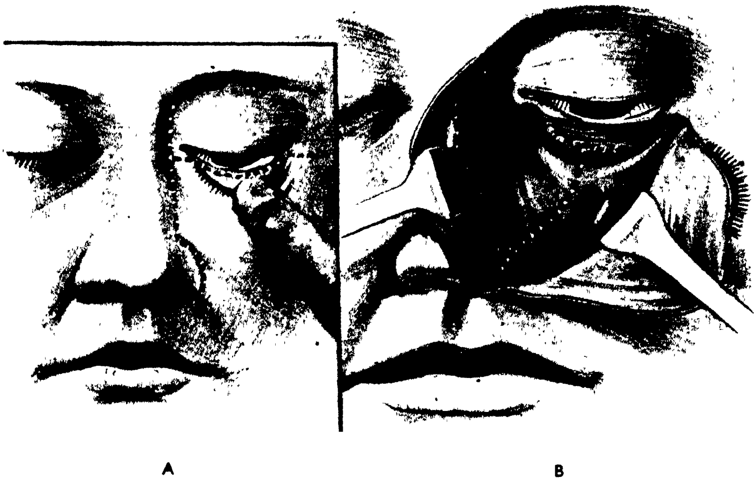

Fig. 676.—Moure's operation.

A, Skin incisions ; B, Flap reflecting bone incisions.

Compared with total removal of the maxilla, this operation has the great advantages that it causes very little deformity and often preserves the orbital plate or the palate, or both, but it does not give nearly such good exposure or drainage as the transpalatal operation.

(3) **Rouge's operation.**—This method is suitable for certain forms of tumour, innocent or malignant, and for removal of large sequestra. The upper lip being everted, an incision is made round the front of the maxillæ in the recess between the lip and the gum, extending backwards

as far as the first molar on each side. With an elevator the soft parts and the periosteum are forcibly separated from the jaws and displaced upwards with the nose. In this manner the pyriform openings of the nasal fossæ are exposed and, if necessary, a large part of the anterior wall of the antrum can be cut away. As with other operations, diathermy rather than cutting should always be employed for removal of malignant growths.

(4) **Total excision of the maxilla.**—The incision is similar to that described in Moure's operation. The front of the maxilla having been exposed, the contents of the orbit are drawn upwards to expose the floor of the orbit. Three cuts are then made through the bone, either with strong bone-forceps or a Hey's saw ; (1) through the nasal process of the superior maxilla and the nasal bone into the nose ; (2) from the spheno-maxillary fissure through the jaw just internal to the zygomatic prominence ; (3) after removal of the central incisor tooth and division of the soft tissues, along the centre of the hard palate from the floor of the nose through the alveolar and palatal processes of the maxilla.

The soft palate having been detached transversely, the whole jaw can now be torn away with lion forceps. Hæmorrhage should at once be arrested either by plugging or by ligature of the vessels. If necessary the external carotid artery must be tied. (*See also* p. 1577.)

(5) **Surface irradiation.**—This treatment should be carefully considered for very advanced disease, both for carcinoma which has extended widely and for the cellular types of sarcoma which may be so malignant that surgery is dangerous. Certain types, such as the anaplastic carcinoma and round-celled sarcoma, are extremely radiosensitive and may disappear completely, at least for a time. Other forms should be rejected as hopeless or the treatment may be advised for palliation of symptoms. Thus hæmorrhage may be temporarily arrested, and pain may be controlled. But it must be remembered that it may be impossible to deliver an adequate " tissue dose " by superficial irradiation alone. Usually, a full course of deep X-rays is the best treatment, for preference given slowly over a period of several weeks, or by a " stop-and-go " method ; or, if available, large quantities of radium, either in the form of a plaque or of a bomb, may be used. In some cases it is better to give a short course of surface rays and to supplement the dose by radium needling. Long needles with 0·6 to 0·8 mm. platinum filters—should be inserted into the nose so that they lie horizontally and irradiate the whole nasal cavity from the front to the naso-pharynx. Needles can also be inserted into the antrum through the outer wall of the nasal fossa or under the upper lip through the incisor fossa. For ethmoidal growths the needles may be inserted partly in the nose or through the skin in a horseshoe arrangement around the inner wall of the orbit. If thick filters such as 0·8 mm. of platinum are employed, there is little danger of severe reactions leading to necrosis of the bones even when large doses are given. This method has been used in a good many cases where the growths have

involved both sides of the nose and the base of the skull and were quite inoperable.

When the postnasal space is also involved, a tube containing 50 mg. of radium with 2 mm. platinum filter is wrapped in enough gauze to fill the space completely and drawn up above the palate by a silk passed through the nose and anchored outside the nostril, or a smaller quantity can be used for shorter periods in split doses. Usually four 5 mgm. radium needles with 1 mm. platinum filtration are fixed in the end of a soft rubber catheter. After cocainizing, this is passed through the back of the nose and anchored with strapping so that radium is in contact with the whole growth. Usually the tubes are retained for ten hours, and at weekly intervals this dose can be repeated until a total dose of about 5,000-6,000 r has been delivered. With split doses given by this means less reaction is produced and better results are obtained than with large single treatments.

Results* (*see* table p. 1431).—The importance of early diagnosis cannot be too strongly emphasized. Without irradiation even localized growths often recur rapidly in spite of extensive excisions, because the wounds become re-infected at the operations. With it this accident is not so likely. Since the introduction of diathermy and radium the operation mortality has also been reduced, owing to the fact that there is less bleeding and less tendency to infection of the lower air-passages than with cutting operations. The results that have been obtained have varied greatly with the different types of disease.

Sarcoma.—Almost all forms of sarcoma met with in other parts of the body are found in the nasal sinuses. They vary greatly in malignancy and can be divided into three groups :—(1) Myeloid and fibrous types : these grow very slowly and rarely metastasize. (2) Chondro-, osteo- and myxo-sarcoma : these are more malignant, more uncertain in their course, apt to recur after operation and, if not cured, to metastasize. A combination of surgery, diathermy and radium is the best treatment. (3) Round-, spindle-celled and melanotic types, which are highly malignant and rapidly form metastases in all parts of the body. This group is very unsuitable for surgery, but usually the growths are highly sensitive and disappear rapidly after irradiation, leaving perfectly normal tissues. In many of them, after a period of a year to eighteen months, local recurrences occur or metastases form in other parts of the body, causing death.

The results obtained by ray treatments of sarcomas are surprisingly good considering that in many cases the growths are extensive and cannot be cured by surgical operations alone. In 1935 I† reported 29 cases treated in the last 12 years, of whom 12 were dead (1 after 5 years), 2 were lost, and 15 were living free from disease (9 for more than 8 years). Two of them had remained well for 4 years, 3 for 7 years, and 1 for 9, 10, 11 and 12 years respectively. These results are very much better than those obtained with sarcomata in other parts of the body or with carcinomata.

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* Harmer in "Radiotherapy in Cancers of the Upper Air Passages," Semon Lecture, Nov. 5, 1931 ; John Murray, London.

† Harmer in "Malignant Diseases of the Upper Jaw," *Lancet*, Jan. 19, 1935, i, 129.

In a series of 259 cases which were collected from other clinics only 42 per cent. were living and well, so that probably the percentage of good results in my cases is higher than may be expected.

Endothelioma.—As is well known, this type of growth shows an inveterate tendency to recur after simple removal in spite of the fact that it is often completely encapsuled. There is evidence to show that this is not so likely if X-rays and radium are employed. As a rule this type of growth should be treated by (1) pre-operative X-rays ; (2) a week later by enucleation of the growth, removing as much of it as possible, and by cauterization of the base of attachment ; (3) by insertion of radium either as a single large dose or in small doses by the split method.

Although these tumours are very difficult to cure, great prolongation of life can be expected in a large percentage of cases. Thus, out of 47 patients treated, 23 are dead, and 24 living for long periods. In many of the patients who died great benefits were derived from treatment, as not only were their lives prolonged but they were also relieved temporarily of much of their distress.

Carcinoma.—This type of growth once it has invaded the bones can seldom be cured. To a large extent this is due to the difficulty of making an early diagnosis. Even a combination of diathermy and irradiation has not given nearly such good results as those obtained in sarcomas and endotheliomas. In early types good results can be expected in about one-third of the cases. For advanced inoperable tumours X-ray treatment may give great temporary relief, but cures can never be expected, either with surface X-rays or interstitial radium. However, hæmorrhage may be arrested, discharge reduced and pain relieved. Early recurrences are common.

In the paper quoted above there were also 70 patients who had been treated for carcinomata ; 45 were dead, the longest survival being 6 years ; 5 were lost ; and 20 were living—2 for 2 years, 5 for 3 years, 1 for 4 years and 6 for 5 years or more.

Ohngren treated 235 patients at the Sabbotsberg Clinic during the years 1924 to 1936. Of these only 120 were followed up for five years or more, and 35 per cent. were living without recurrence for 5 to 12 years. Better results have been obtained with diathermy alone, except when metastases were also present. In 24 per cent. treated by diathermy, block dissections and irradiation, all the patients had died within 3½ years. Twenty-two patients were treated by irradiation only, of whom 5 lived for 5 to 9 years.

In border-line groups some cases may be relieved for long periods, but in inoperable types with metastases any treatment should be regarded as only palliative. In many, temporary improvement may be obtained.

Actually, the results were better than the tables suggest, because in many of the patients who died the growths were temporarily arrested and their symptoms were greatly relieved. Undoubtedly in recent years the results have been better, owing to a more intelligent combination of surgery, diathermy and irradiation..

OPERATIONS ON THE PHARYNX

Operations on Abscesses

Peritonsillar.—With acute inflammations, pus may collect in or behind a tonsil (quinsy), but it is often difficult to diagnose and to locate such an abscess. If pus is suspected the swelling should be explored. A solution of cocaine (10 per cent.) should be applied to the tonsil and also to the front of the sphenoid so as to block the external and posterior palatine nerves passing from the spheno-palatine ganglion to the tonsil. A strong probe bent at a right angle should be forced through the supra-tonsillar crypt in various directions, and if an abscess is pricked the sinus can easily be dilated with forceps. This is the most reliable method of treating a quinsy. If, however, an incision is preferred, a guarded knife may be used and plunged boldly into the prominent part of the swelling through the soft palate. To cure a chronic abscess it is generally necessary to perform tonsillectomy.

Retropharyngeal.—Acute abscesses which develop in the loose cellular tissue behind the pharynx usually produce an elongated swelling of its posterior wall. In such a case a longitudinal incision should be made into the most prominent part, and the abscess drained into the pharynx. When under general anæsthesia, the patient should lie on his side so that pus may not enter the larynx. Chronic abscesses cause firm, painless swellings on the posterior pharyngeal wall, usually on one side behind the pillars of the fauces. Without exploration they may be difficult to distinguish from slowly-growing tumours such as sarcomata. They may be due to trauma or foreign body, resulting in any form of bacterial or tuberculous infection, or cervical caries involving the retropharyngeal glands or prevertebral tissues. They can be easily opened by an incision through the prominent part of the swelling in the pharyngeal wall; this is a much simpler treatment than an approach through the neck, and actually gives a quicker cure in most cases, the sinus healing well in a short time even when due to chronic tuberculosis.

In some cases, especially when there is also a prominent swelling in the neck, it may be better to open by an external incision and so prevent secondary infection from the mouth.

Operations on the Tonsils

Removal of the tonsils is one of the most frequently required operations of surgery, and when adenoids are present they should be treated at the same time. Tonsillotomy, namely removal of the prominent part of the tonsil, is sometimes practised for simple enlargement causing obstruction to breathing or other discomfort in children under five. There are, however, so many conditions which cannot be cured by this treatment that it has been almost discarded by most specialists. Tonsillectomy, which implies removal of all the tonsillar tissue with the capsule intact, is a much more difficult undertaking and should only be advised after careful consideration. In recent times it has become so popular that in some of the public schools as many as 80 per cent. of the children have had their tonsils removed. Unfortunately, the after-results have not been nearly as satisfactory as was expected, and catarrhal infections of the upper air-passages are worse now than when fewer operations were performed.

Indications.—Indications for tonsillectomy include infected tonsils and adenoids in children ; recurrent tonsillitis or quinsy ; failure of tonsillotomy and removal of infected tonsillar remains ; enlarged glands in the neck, simple or tuberculous ; tonsillar sepsis associated with general debility ; catarrhal infections of naso-pharynx, sinuses, ears and lower air-passages ; rheumatism ; certain infections of the lungs, heart, kidneys and nervous system ; goitre ; malignant disease ; infections of the eyes or of the gastro-intestinal tract ; or in fact any form of toxæmia in which it is believed that the tonsils may be sensitizing agents. In doubtful cases a bacteriological examination of the secretion from the crypts should be made, and if cultures show heavy infections, particularly with hæmolytic organisms, the tonsils should be condemned.

Anæsthetic.—On the Continent and in America local anæsthetics are generally employed, but exceptions are made if the patient has a sensitive throat or if he is nervous. They should not be employed against the wish of the patient, or in children under fourteen. To obtain a satisfactory anæsthesia the surface of the tonsil should be painted with cocaine (10 per cent.) and the deeper parts infiltrated with a solution of novocain (2 per cent.).

General anæsthesia is preferred by most British people, both surgeons and patients. The importance of an anæsthetist not only skilled but accustomed to this type of work cannot be too strongly emphasized. For guillotine operations in children in out-patient departments, open ether, A.C.E. mixture or chloride of ethyl are in common use. Chloroform is not so safe and should never be given alone.

The anæsthetic is one of the principal dangers of the operation. Many patients dread it, and some form of preliminary medication is advisable for those of nervous temperament. In children a capsule of nembutal, gr. 1 to 2, produces drowsiness and prevents their being frightened or shocked. In adults some simple injection such as morphia and atropine may be sufficient, or unconsciousness can be produced by rectal avertin or paraldehyde or by intravenous injection of evipan or pentothal. Satisfactory anæsthesia can be obtained with gas-and-oxygen and small amounts of ether, or A.C.E. mixtures.

Position.—The patient may be placed in any of the four recognized positions, namely, sitting in a chair, lying on a flat table, lying with the head extended so that it hangs over the end of the table, lying on the right side. The last is the best, because in this position blood runs out of the mouth and the breathing is never obstructed. The surgeon should sit on a low stool facing the patient, with an assistant on his right side to depress the tongue and to sponge out the blood. A suction apparatus is also of great value in removing blood and mucus.

Tonsillotomy.—This is usually performed with a guillotine. The mouth is opened widely with a gag, and the anæsthetist forces the tonsil inwards and upwards by pressing on the neck behind the angle of the jaw. For the right tonsil the guillotine is taken in the left hand and applied as near the tongue as possible, so that the lower part of the tonsil is included. It is drawn firmly outwards and upwards, and the first finger of the right hand is employed to ascertain if the tonsil is projecting through the guillotine. As much as possible should be removed by a sudden sharp closure of the blade. In those cases where the tonsil cannot be pressed through the guillotine from outside, the surgeon must either pull it into position with a tenaculum or employ the method of Whillis and Sluder. The left tonsil should then be quickly removed with the guillotine grasped by the right hand ; or, if preferred, by using two guillotines and both hands, both tonsils can be dealt with simultaneously. To arrest hæmorrhage, sponges are pressed on the tonsils, and if the patient is breathing satisfactorily the adenoids are avulsed.

Tonsillectomy (enucleation of the tonsils).—The tonsils, however adherent, should be removed cleanly, with their capsules intact. Even in experienced hands this may be difficult. Having seen and extensively employed many different methods, I have come to the conclusion that the following operations fulfil all requirements.

Method of Whillis and Sluder.—This excellent operation is chiefly employed in out-patient departments, where speed is essential, and is applicable in the majority of cases, especially in children. The reverse side of a guillotine with a blunted edge is applied to the tonsil so as to lever it upwards and outwards. The handle of the instrument is directed towards the angle of the mouth on the opposite side and firm pressure is applied to it to force the guillotine against the wall of the pharynx, thus causing the tonsil to bulge into the anterior pillar and soft palate. With the tip of the *thumb* the supratonsillar portion of the soft palate and the tonsil are pressed through the opening in the guillotine and steadied while the blade is closed sufficiently to engage the tonsil. It is important to see that the blade passes posterior to the reflection of the mucous membrane behind the edge of the anterior pillar.

The thumb must be removed before the blade is pushed home, otherwise the palate will be buttonholed. A momentary inspection shows that the uvula is free and that the whole tonsil lies on the inner side of the guillotine. The blade is then forced home. With a blunted instrument considerable pressure is required, but if the vessels are crushed there is less bleeding than when cut by a sharp knife.

The tonsil having been removed, a sponge is inserted into the fossa by an assistant, and pressure is maintained on it for a few minutes while the surgeon examines the tonsil to see that the capsule is complete. The second tonsil can afterwards be removed in the same way.

Hæmorrhage is more efficiently controlled if bleeding-points are picked up with fine-pointed artery forceps and ligatured. In this manner the first tonsil bed is rendered quite dry before the second tonsil is removed ; the bed of the latter is treated in the same way.

Tonsillectomy (by dissection).—This is a more reliable method in adults or in children when the tonsils are very adherent. It has the further advantage that it causes less bruising than the guillotine. The tongue being depressed by the assistant, the right tonsil is seized with a tenaculum and drawn inwards and forwards from its bed. With a small sharp periosteal elevator the mucosa is divided on the tonsillar side of the anterior pillar around the arch of the fauces and down the posterior pillar. These incisions should be superficial, and should cut neither the pillars nor the capsule of the tonsil. This part of the dissection requires great patience and delicacy, and it is most important that the pillars should not be torn or denuded of their membranes, or scarring and deformity will result. The elevator is now introduced more deeply behind the upper pole of the tonsil, and is swept around it so as to dislocate it from the fossa. The tonsil can now be quickly separated from its bed by traction downwards and by separating the tissues with a strip of gauze or by a blunt dissector. The lower part, being now isolated, can rapidly be removed by a wire snare such as Eve's, placing the barrel of the snare in the supratonsillar fossa, and the loop over the lower end of the tonsil. (Fig. 677.) Sponge pressure is applied temporarily while the tonsil is examined.

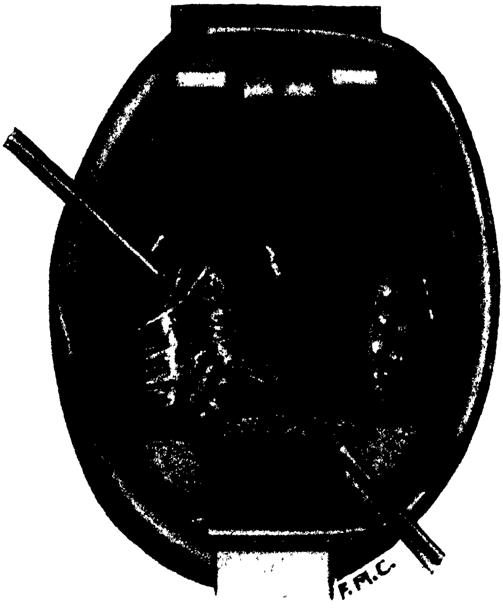

Fig. 677.—Enucleation of tonsil with snare.
A, Intra-tracheal tube ; B, pharyngeal pack.

The parts of the tonsil that are most often missed are the lower pole near the tongue and the superior lobe under the supratonsillar fold. If necessary, the snare must be used again to remove them, otherwise these stumps may give rise to further attacks of tonsillitis, or may hypertrophy to such an extent that they fill the fossæ again.

After tonsillectomy a careful search should be made for bleeding vessels, which may be either veins or arteries. From the former the blood is dark and wells up rapidly, which makes it easy to detect. The arteries in this region, being generally small, are more difficult to see. The blood from them is bright red and spurts across the pharynx in a fine stream, splashing the opposite wall. Sometimes the fossa fills so quickly that the site of the bleeding is difficult to determine. The cut vessels are often found near the tongue and under the supratonsillar fold. The first essential is to prevent too much blood from collecting in the pharynx so that respiration becomes difficult, and above all to ensure that blood is not aspirated into the lower air-passages. The second tonsil should never be removed until the hæmorrhage from the first tonsillar fossa has been completely arrested. *A rule should be made never to allow the patient to leave the operating-table until all bleeding has ceased.* The better method is to pick up and tie the different vessels with linen threads or fine catgut, using the slipknot of Coakley. (Fig. 678.) In rare instances where the bleeding cannot be controlled with ligatures a small swab of gauze should be placed in the fossa, and the pillars of the fauces sewn together

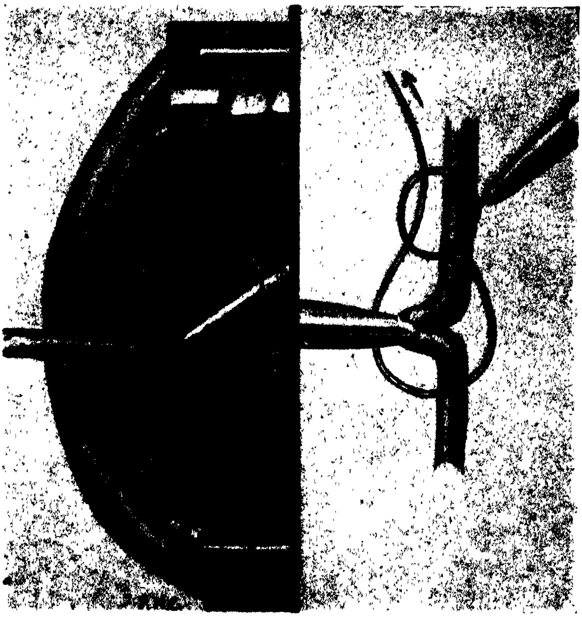

Fig. 678.—Ligature of tonsillar vessels (Coakley's knot).

over it. (Fig. 679.) Only by such means is it possible to save the patients from the distress and dangers of prolonged bleeding.

Dangers and complications.—The *anæsthetic* is still regarded by the public as the chief danger of the operation. Unfortunately, deaths are constantly reported, children being the principal victims. The majority of these accidents are due to chloroform.

Hæmorrhage may also be alarming after the patient returns to bed, but is rarely serious if proper precautions are observed. When very severe, the patient becomes pale and restless, the pulse-rate rapid; also there is repeated vomiting of gastric fluid with dark clots and bright streaks of blood. Recurrent hæmorrhage occurs mostly during the first six hours after operation, true secondary hæmorrhage resulting from sepsis between the 4th and 7th days. The brighter the blood the more important it becomes to treat the cause. The throat should at once be inspected to ascertain the source of the bleeding. Usually a large clot is seen in one or both fossæ, or the blood may be coming from the naso-pharynx. If the bleeding is getting steadily less and the vomited material darker in colour and smaller in amount, the tonsillar clots should not be disturbed. The patient should be kept quiet, and if necessary an injection of morphia should be given. If hæmorrhage does not cease, especially if the patient becomes faint and restless, and the ordinary methods such as sitting up, sucking ice, sponge pressure with pure peroxide of hydrogen or adrenalin have failed, the surgeon must never leave the patient or hesitate to ligature bleeding spots or to suture the pillars of the fauces firmly over plugs of gauze. By using special Michel's clips this can be done rapidly and successfully in most cases. But if the patient is very nervous a second anæsthetic is usually advisable and the pillars should be sutured over a gauze pad with two or more linen threads. (Fig. 679.) If the gauze pad is securely inserted it rarely fails to arrest the hæmorrhage and, if Bipp is used, can be left *in situ* for forty-eight hours.

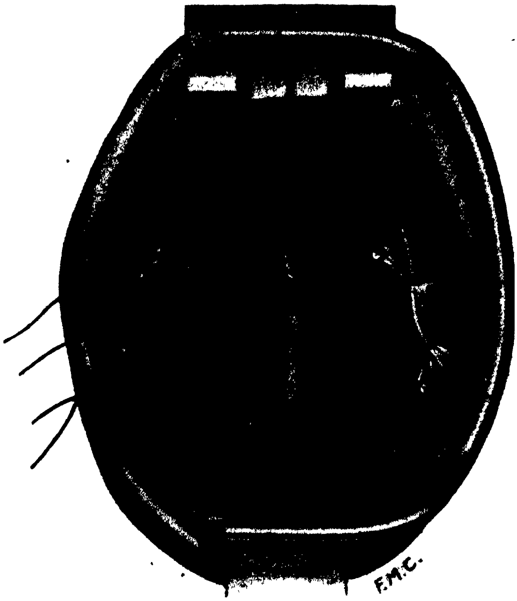

Fig. 679.—Suture of pillars of fauces over gauze pad.

Such treatment of the wound is much safer and easier than ligature of the external carotid artery, which should be reserved for those rare cases where an abnormally placed carotid vessel has been wounded.

Shock should be treated by repeated injections of saline and glucose into the rectum, subcutaneous tissues, or veins. For persistent oozing, such as occurs in " bleeders," an injection of some form of hæmostatic serum may be given. But it must be remembered that usually these are valueless, and if the bleeding is serious direct blood-transfusion is essential, as it is the only effective treatment and should be insisted upon as long as there is a chance of saving the patient's life.

Sepsis.—The amount of inflammation varies unaccountably after tonsillectomy, and appears to depend on some personal factor more than upon the degree of sepsis at the time of the operation. The soreness is always localized, and apart from the pain is rarely serious, nor does it persist for many days except in syphilitic subjects. Referred pain in the ear is common, but infection through the Eustachian tubes is fortunately rare, as is any other complication.

To prevent infection of the throat, it is important to treat radically any dental sepsis before the operation, to use an aspirator for the blood and so avoid bruising from constant sponging, and afterwards to get the patient to gargle frequently with mild antiseptics. Patients suffering from hæmolytic streptococcic infections should be given sulphonamide for two days before operation and afterwards if necessary. For the past year one of us (W.D.H.) has applied sulphamezathine powder with an insufflator to the tonsillar fossæ after all bleeding has been arrested, and this is repeated two or three times daily for a short period, if necessary. Such local applications have been found to prevent infection and to promote good healing.

Cauterization.—This method of treating infected tonsils is only advisable in certain selected patients when a more formidable operation is contra-indicated. A simple electro-cautery may be used to slit up infected crypts or for cautery puncture to reduce hypertrophy. In recent years diathermy has become much more popular. The advantages claimed are of some importance: local anæsthesia is sufficient, the patient is not confined to bed or hospital, pain is rarely severe, and bleeding is uncommon and not often severe. On the other hand, some patients find the treatment irksome because six or more sittings are usually necessary. The main objection is the difficulty of removing the whole of the tonsillar tissue. If scarred stumps are left they may produce more toxæmia than before treatment. In the hands of a few specialists diathermy is a useful treatment in the out-patient department, but it is in no sense as reliable as a skilful enucleation.

REMOVAL OF ADENOIDS

The removal of adenoids, one of the commonest operations of childhood, is rarely necessary before 12 months of age or after puberty. Although a simple undertaking, which can be completed in a few moments, the same precaution should be observed as with operations on the tonsils. Except in very young children, the two treatments are generally carried out at the same sitting.

Indications.—Nasal obstruction causing deformities of the nose, mouth, teeth, or chest; persistent catarrh leading to repeated colds, laryngitis, bronchitis, or infections of the Eustachian tubes and ears; sepsis resulting in enlargement of glands and general debility; reflex nervous conditions such as asthma, night terrors, convulsions, enuresis, cough, laryngismus stridulus. For these conditions, operations give results far superior to any other line of treatment.

Anæsthetic.—Either gas-oxygen-ether, or a whiff of chloride of ethyl followed by open ether, is the best anæsthetic. Chloroform alone should never be employed. For highly nervous children a preliminary dose of nembutal by the mouth is advisable.

Operation.—The patient is on his right side. The mouth being held widely open with a gag, a curette grasped in the right hand is passed behind the soft palate as high as possible into the naso-pharynx. The instrument, which must be kept exactly in the middle line, is pressed firmly against the posterior wall of the pharynx, and the adenoids are removed by making a quick sweep down towards the tongue. If the patient's head is thrown back too far, the bodies of the vertebræ may project so much that the knife cannot pass over them easily. For this reason the anæsthetist should be prepared to tip the head forward just before the adenoids are removed. If the cut is made boldly the pad will be caught by the cage and removed *en bloc* with the instrument. Failing this, it will be found hanging by a tag at the back of the throat and must be avulsed. The lateral fossæ are then examined with the finger, and tags either scraped away or removed with curved forceps. Care must be taken not to wound the uvula or the pillars of the fauces. Hæmorrhage is usually free, and the patient should be turned over so that the blood may run out of the mouth. If necessary, continuous sponge-pressure can be applied, and usually the bleeding ceases. But, more rarely, it may be so persistent and severe as to require a second anæsthetic and post-nasal plugging. No local after-treatment is necessary, and nasal douches should be avoided for fear of infection of the ears. Deafness, earache or otitis media may supervene, but such complications are rare.

REMOVAL OF TUMOURS

INNOCENT TUMOURS

Papillomata, adenomata, cysts, angiomata, and other benign tumours of the pharynx are rarely of great importance and, being small, can easily be removed with scissors or snares.

Naso-pharyngeal polypus (fibro-angioma).—This growth originates in the periosteum covering the basi-occipital and sphenoid bones. Growing rapidly, it may extend forwards and invade the nasal fossa, the antrum, the sphenoidal cells, or the orbit; or it may spread outwards into the parotid region. The tumour is encapsuled, and has a broad attachment to the base of the skull, through which it obtains a very free blood supply. Lying in an irregular cavity at the back of the nasal fossa, it becomes so firmly impacted that it can only be removed with difficulty. It is impossible to ascertain the exact boundaries even of small growths, and bleeding may be serious. It is advisable to employ an intratracheal tube for the anæsthetic, or to perform a preliminary laryngotomy and to pack the pharynx with gauze so that blood cannot pass into the lower air-passages during the operation. Also, as the amount of bleeding can never be foreseen, preparation should be made in every case for intravenous injection of saline-glucose or, if necessary, for blood transfusion, before the patient leaves the table. For a large pulsating tumour causing " frog-face," temporary ligatures or Crile's clamps should also be applied to both external carotids before attempting removal, and preparations should be made for blood transfusion or the intravenous injection of saline-glucose solution.

Access to the tumour may be obtained by the following routes : (1) If the mouth is opened fully with a gag and the soft palate is drawn forwards with a suitable retractor, a small tumour can be separated from the base of the skull by a strong raspatory and removed rapidly. (2) To obtain a free exposure of a tumour which involves the posterior part of the nasal fossa it may be necessary to split the palate longitudinally and, having reflected it, to cut away most of the bony palate. After removal of the tumour the palate should be repaired. (3) The nasal route may be preferable for a large tumour involving the accessory sinuses. *Lateral rhinotomy* (*Moure's operation*, p. 1410) gives very good exposure for cases with much swelling of the face, but the transantral method (p. 1398) through the canine fossa may be even better, and is often preferable because it causes less deformity. *Rouge's operation* (p. 1411) does not give as good an exposure as the other methods. (4) Temporary resection of the maxilla (*Langenbeck's operation*) should never be necessary.

By one of these methods the tumour must be freely exposed and its base of attachment defined. A strong raspatory should be employed to force it off the bone as rapidly as possible. Care must be taken to remove the whole of the growth. In some instances part of the base of the skull is removed, thus exposing dura mater, which is rarely involved. The cavity should be firmly packed for several minutes, and afterwards examined for bleeding-points, which should be ligatured. After complete removal of such a growth there seems to be little danger of hæmorrhage, but it is advisable to pack the wound lightly with Bipp gauze for forty-eight hours. A long operation may be followed by severe shock from loss of blood, and careful after-treatment is essential. The wound usually heals well, and complications such as sepsis and meningitis are rare. The prognosis also is good, but a true fibro-angioma may recur, especially when incompletely removed, in which case the recurrence should be destroyed at an early stage by diathermy. A fibro-sarcoma originating in this situation is difficult to distinguish from the non-malignant polypus, and is more difficult to eradicate.

MALIGNANT TUMOURS

These are comparatively common in the pharynx and usually highly malignant. Growing rapidly, they become inflamed and ulcerated at an early stage. As they are rarely encapsuled it is difficult to determine their exact limits. Usually they are far advanced before the patient seeks advice and in most cases the neighbouring structures are involved, such as the muscles of the pharynx, the palate, the larynx, the tongue, the tonsil or the bones of the skull and the jaws. Metastases in the glands in the neck occur early, and in operable cases a complete dissection on one or both sides may be necessary. With sarcomas, metastases in other parts of the body often occur unless the disease is treated early. As there is an inveterate tendency to recurrence after cutting operations most of these cases are truly inoperable. The early diagnosis of malignant disease in these regions is very important, but as the growths are so highly malignant it is advisable always to give them irradiation before trying to confirm the diagnosis by a biopsy.

The forms met with include *carcinoma* (usually squamous-celled), which commonly originates in the tonsil, in the pyriform fossa (*see* p. 1456), or more rarely in the naso-pharynx ; *sarcoma* (*round-celled or lympho-sarcoma*), which is rarer, and commences in the tonsil, or in the soft palate or naso-pharynx ; *endothelioma*, which may also start in the soft palate, in the pharyngeal wall near the tonsil, or in the naso-pharynx in the neighbourhood of the Eustachian tube.

The choice of treatment of these tumours is still a matter of great difficulty. To be successful, a combination of surgery, diathermy, X-rays and radium is essential and, generally speaking, the treatment should be planned in consultation between experts in these different methods. Surgery alone should only be undertaken when the growth can be removed freely without cutting into it. Everyone is agreed about the danger of dissemination. For this reason, local removal with knife or scissors, say for a growth of the tonsil, should never be attempted.

External operations.—**Pharyngotomy** may be performed for the exposure and treatment of early malignant disease originating in any part of the pharynx below the level of the palate, namely, for growths of the tonsil, the base of the tongue and epiglottis, of the pyriform fossa, or postcricoid region. The anæsthetic is administered either with an intratracheal tube or more frequently through a tracheotomy cannula.

Median pharyngotomy.—Binnie's excellent description of the different methods* may be thus summarized :

Subhyoid route.—A transverse incision, 2 in. or longer, is made along the lower border of the hyoid bone. The platysma, the omo-hyoid, the sterno-hyoid, and the sterno-thyroid muscles and also the thyrohyoid membrane are successively divided. The mucosa is then nicked where it is free from the growth, and the opening is enlarged by stretching. This method exposes the upper opening of the larynx, and a growth in this position can be readily excised. If possible, the epiglottis should be pulled aside, and not injured. If a large portion of the pharynx has been excised the wound should be packed with gauze, but it is better to suture the mucosa and afterwards the thyrohyoid membrane, muscles, and skin in turn, leaving a small tube in the wound for drainage.

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* "Operative Surgery."

Transhyoid route.—A median incision is made, the mylo-hyoid muscles are separated, and the hyoid bone is divided. Retraction of the structures gives a space of 1½ in. in which the mucosa can be divided. After removal of the tumour the wound should be treated as before.

Suprahyoid route.—A concave incision above the hyoid is employed. The submaxillary glands are retracted. The mylo-hyoid, the genio-hyoid and the genio-glossus muscles are divided, if possible preserving the insertions of the digastric muscles. When the pharynx is opened, the soft palate, the tonsils, the epiglottis and the base of the tongue can all be exposed.

Lateral pharyngotomy.—Trotter* elaborated the methods of performing this operation. He pointed out that to obtain a cure, free exposure of the tumour is essential before removal is attempted, and considered that the lateral route is superior to any other because by this means the whole length of the pharynx and even the cervical œsophagus can be laid open. To obtain access to the tonsil, the pillars of the fauces, or the base of the tongue, the mandible is divided in front of the masseter and the superior constrictor muscle is incised in front of the tonsil (superior lateral pharyngotomy). (Fig. 680.)

By removal of the great cornu of the hyoid bone and the ala of the thyroid cartilage, the middle and inferior constrictors can be divided, with the aponeurosis of the pharynx, giving access to the pyriform fossa, the upper opening of the larynx, the postcricoid region and, by extension downwards, the cervical œsophagus (inferior lateral pharyngotomy). In many instances neither of these routes gives sufficient exposure, in which case Trotter recommends combined lateral pharyngotomy.

Combined lateral pharyngotomy.—The steps are as follows: (1) Preliminary tracheotomy. (2) Incisions along the anterior border of the sterno-mastoid muscle from the ear to the cricoid, and through the middle of the lower lip, over the chin, and below the lower border of the jaw, to join the first incision. (3) Exposure of the submaxillary and anterior triangles of the neck. (4) Division of the posterior belly of the digastric and stylo-hyoid muscles, the common facial vein, the superior thyroid, lingual and facial arteries. The next step consists in suturing the sterno-mastoid muscle to the prevertebral muscles to shut off the carotid region from the operation area. This is an important step, for if some such method is not adopted there is considerable risk of sepsis reaching the deep fascial planes of the neck, and even infecting the mediastinum. The superior laryngeal, lingual, and hypoglossal nerves must be divided, but the last should be resutured. The infra-hyoid muscle and the middle and inferior constrictors are detached, the great cornu of the hyoid bone and the thyroid ala are removed, and the mandible divided. It is then possible to incise the whole lateral wall of the pharynx without cutting into the growth. By this means a very free exposure can be obtained, and it will then be seen with certainty whether the growth can be removed.

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* *Journ. Laryn., Rhin., Otol.*, Oct., 1920, xxv, 289.

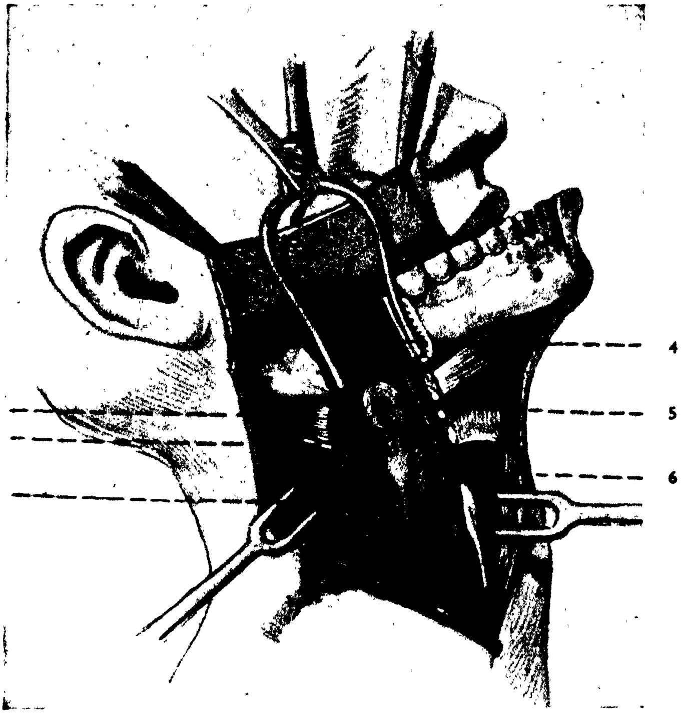

Fig. 680.—Lateral pharyngotomy (Trotter's operation).

1, Digastric muscle; 2, hypoglossal nerve; 3, sterno-mastoid sutured over carotid sheath; 4, tongue; 5, epiglottis; 6, pharyngeal wall.

Although this may seem a very drastic means of obtaining access to a growth in the pharynx, it is said to give better results and to be followed by very little shock. The patient should be made edentulous before operation to diminish the risk of sepsis and necrosis of the jaw. Trotter considered this most important.

After this treatment, complex plastic operations may be necessary with a view to restoring the functions of respiration, speech, and deglutition, and it is necessary to provide for this in planning the incision. In some cases a permanent tracheotomy-tube has to be worn.

Pharyngo-laryngectomy, although more extensive and mutilating, is an alternative operation which is considered by some surgeons less dangerous than pharyngectomy, except when the growth is small and localized to the pharyngeal wall. Good results have been reported after this operation, a case of Arthur Evans's surviving for 23 years and two cases of Stanford Cade's living free from disease for 4½ and 5½ years respectively. Unfortunately, all pharyngeal operations have considerable mortality owing to infection.

Treatment by diathermy.—An apparatus is required which can produce currents both for rapid cutting and for slow coagulation, these being the two principal methods of treating a growth by cauterization. The different techniques that can be employed are :

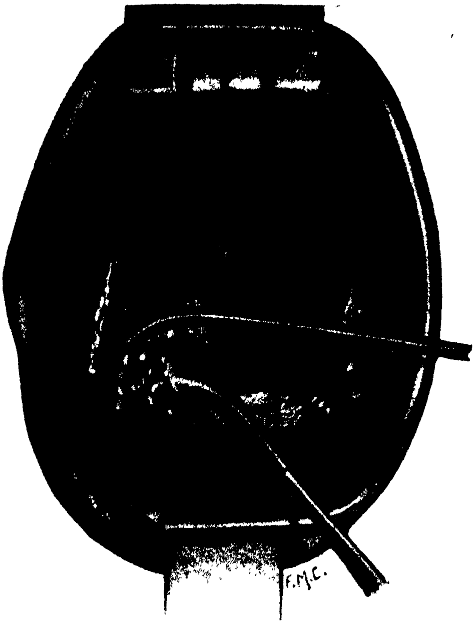

Fig. 681.—Diathermy. Removal of growth by cutting current.

A, intratracheal tube ; B, pharyngeal pack.

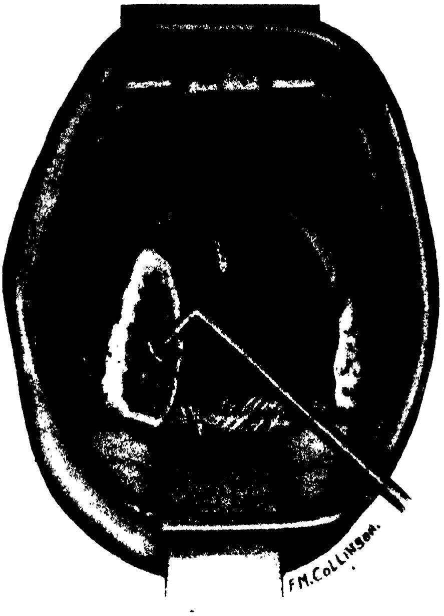

Fig. 682.—Diathermy destruction of growth by coagulation.

Fulguration.—A single needle-electrode is placed close to the growth but not quite touching it and fine sparks are sprayed over it. The tissues are deprived of water and rapidly converted into a dry mass. The heat does not penetrate more than a few millimetres so that the treatment is only suitable for superficial warts or patches of leucoplakia, or as a preliminary to render a growth less likely to bleed or break.

Endotherm knife.—A needle or fine knife is used as the electrode. (Fig. 681.) With the proper current, tissues can be rapidly divided and if the knife is moved quickly the heat does not penetrate more than a few millimetres. So little coagulation occurs that there is hardly any sloughing of the tissues afterwards and in certain cases the wound may be safely sutured. Excision with the cutting current is the best method of removing growths of the tonsil, lateral pharyngeal wall, uvula or palate, irrespective of the exposure employed.

Coagulation.—A small button-electrode (Fig. 682) can be applied to the surface of a growth and a weak current switched on for ten to twenty seconds, by which time the neighbouring tissues are blanched, and this can be repeated until the lesion has been completely destroyed. The necrosed parts can then be removed with a sharp spoon. Or a long needle can be passed deeply into the tissues around the ulcer and used for slow coagulation. By repeated punctures the whole growth can thus be isolated (circumvallation). With both these methods it is important to remember that the heat penetrates to a great distance, far beyond the region that is being treated, and if applied for too long may cause deep sloughing of the wound, and serious hæmorrhage when the disease is close to important vessels. Coagulation is useful for destruction of growths in the naso-pharynx, the tonsillar fossa, and base of the tongue, and occasionally in the deeper pharynx.

With diathermy it is possible to destroy localized malignant ulcers completely, safely and quickly. Even with vascular growths the operation is bloodless. Afterwards the absence of pain is remarkable. The wound becomes covered with thick sloughs and heals slowly in from ten to fourteen days. These sloughs rarely cause any inflammation of surrounding tissues, toxæmia, or rise of temperature. When bone has been destroyed, a dry painless sequestrum is produced which may not separate for several months. Secondary hæmorrhage is so rare that it is only necessary to perform a preliminary ligature of the external carotid arteries when operating on extensive growths involving the tonsil and base of the tongue. Ultimately the area treated becomes covered with a soft healthy mucosa, and very little scarring results. The advantages claimed for this method are the ease and rapidity of the operation, which can be performed without loss of blood, the absence of inflammation, so that no pain, sepsis or toxæmia supervenes, and the healthy wound which results. When treated by diathermy, malignant disease is less likely to recur than after cutting operations.

Treatment of glands.—Secondary deposits in the glands of the neck are common and always make prognosis unfavourable. The treatment depends on the following conditions :

(1) **Type of growth.**—Broders and others have shown that this is very important. In rapidly-growing cellular forms, the so-called Grade 1 types, it is doubtful whether dissection can give good results. In fact there is a danger that the growths may be stimulated to greater activity. Such cases should, therefore, be treated by irradiation. On the other hand the low-grade tumours are more favourable for surgery.

(2) **Glands not palpable.**—If the primary growth is not very virulent, the neck need not be treated but should be examined periodically for at least twelve months to make sure that there are no metastases.

(3) **Glands suspected.**—For small indefinite glands, particularly if widely distributed, it is difficult to decide whether to operate or not, and irradiation may be preferable.

(4) **Glands enlarged.**—Block dissections should always be undertaken if the primary growth can be successfully treated ; if the glands are unilateral, localized, movable and absolutely operable (not border-line) ; and if the general health is good with a reasonable expectation of life. If necessary, a part or the whole of the sternomastoid muscle should be removed. If there is doubt whether all the disease has been eradicated, the neck should afterwards be given a full treatment with irradiation. Some of the best ray results are obtained in cases where the greater part of the glands has been removed.

Multiple glands on one or both sides of the neck, extending low down towards the clavicles, and especially if very adherent to other structures, should always be regarded as inoperable. In some such cases good results can be obtained by radium implantation or by surface irradiation ; but each case must be considered individually, especially with regard to expectation of life.

Radiation.—Cancers of the pharynx may be so malignant that they cannot be satisfactorily treated without radiation. For rapidly-growing tumours such as lympho-sarcomata and lympho-epitheliomata it is unquestionably the only safe treatment. It may also be of great value in border-line and inoperable growths.

X-rays.—Massive doses produced by tubes working with 200 volts or more have given the best results.

Radium bombs.—Bombs containing 1 to 5 grammes of radium are used in some clinics, either alone or in combination with X-rays.

Radium collars.—Usually large doses are employed. A number of 5-mgm. tubes is uniformly distributed to cover the affected area, and the collar is worn daily for definite periods until an adequate dose has been delivered.

Radium implantation.—This is a valuable method whereby a dose of high intensity can be delivered to a growth in the tonsil or pharyngeal wall. To obtain uniform irradiation the needles or radon seeds must be buried in the primary growth and in the neck. Usually, the former is treated first and the glands after a short interval. Under exceptional circumstances the radium can be inserted into the tonsil and into the neck at the same sitting. For a large growth, ten or more needles containing 1 to 2 mgm. with 0.6 or 0.8 mm. platinum filters are inserted and left *in situ* for 5 to 10 days. The needles should be placed in pairs, lying parallel, with their points in opposite directions, one string of each pair being tied together to prevent slipping. (Fig. 683.) The second string attached to each needle should be brought through the mouth or through the naso-pharynx and nose and fixed to the skin of the face. Later this is used for the removal of the needle.

In the neck a large number of needles containing 2 or 3 mgm. of radium or radon seeds may be required. Usually, they are pushed through the skin and uniformly distributed over a wide area, but great care must be taken not to damage important vessels. If an open operation is employed, the skin should be accurately sutured and every effort made to keep the wound aseptic. To remove the needles, the wound is re-opened but, if possible, should at once be closed by sutures inserted at the first operation.

In early cases radium implantation may cause complete disappearance of the growths. Even late growths generally shrink. Ulcers may heal, pain and distress may be alleviated, hæmorrhage and discharge may be arrested and life considerably prolonged. In many cases fibrous tissue is produced and may remain inactive although it actually contains cancer cells. Usually, such remnants do not respond well to further irradiation but whenever possible they should be freely excised by diathermy. Malignant tumours of the naso-pharynx are very difficult to treat. The growths are so deeply situated and often so extensive that they can rarely be cured by any form of surface irradiation. Some cases can be treated by radium tubes enclosed in a rubber catheter, which is passed through the nose so that the radium is in close contact with the growths. Experience has shown that a better plan is exposure of the post-nasal space through the transantral approach. This gives a very good access to a growth in this situation and makes it possible to remove it by diathermy or to treat it with contact radium introduced on a moulded stent. Usually, the radium is introduced for four to six hours daily, and the treatment is continued until at least 5,000 r has been given.

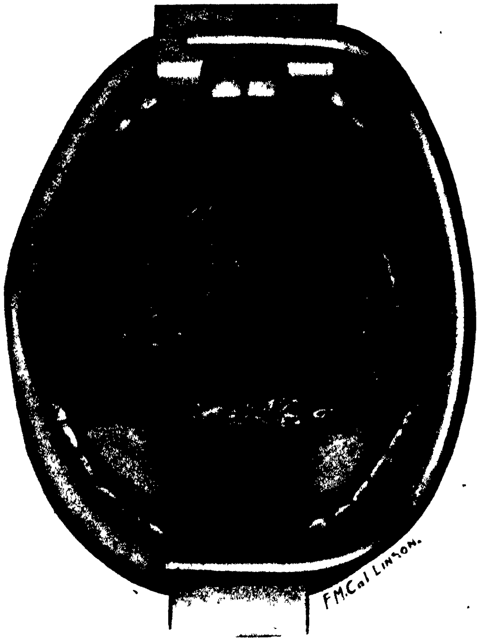

Fig. 683.—Insertion of radium needles in tonsil.

Results.*—Results obtained by surgery, diathermy and irradiation treated in 20 clinics in this and other countries were reported in 1931 :

		Cases	*Dead*	*Not Traced*	*Living free from Disease*	*Living 5 years or more*
CARCINOMA .	Nasal Sinuses	819	427	136	256	63
	Naso-pharynx	86	76	—	10	—
	Tonsil . .	606	381	99	126	16
	Pharynx and Hypopharynx	705	563	41	101	7
		2,216	1,447	276	493	86
SARCOMA .	Nasal Sinuses	86	48	5	33	10
	Naso-pharynx	31	15	—	16	2
	Tonsil . .	92	59	—	33	18
	Pharynx and Hypopharynx	11	6	1	4	—
		220	128	6	86	30
ENDOTHELIOMA	Naso-pharynx and Palate	47	23	—	24	2

It will be seen that *carcinoma* is the worst type of malignant disease in the pharynx and that it is much more difficult to cure than in the nasal sinuses. An analysis of the cases showed that good primary results were obtained in about 25 per cent. but that recurrences, particularly in the glands, were common after the first year so that very few patients survived for five years or longer.

In the naso-pharynx five-year cures are also extremely rare ; in the tonsil they are difficult to obtain but in recent years reports have improved ; thus Patterson,† using diathermy, reported 51 cases of whom 11, i.e. 20 per cent., lived for over five years, the longest survival being 14 years. In the hypo-pharynx 5-year survivals were also uncommon, but Trotter has obtained lasting cures with lateral pharyngectomy, and the results obtained by radium beam and by deep X-rays are certainly improving.

Endotheliomata, which are probably adeno-carcinomata and show an inveterate tendency to local recurrence, are very difficult to cure, but great prolongation of life can be expected in about 50 per cent. of cases.

Sarcomata, although varying greatly in their malignancy, respond to treatment far better than carcinomata. Good primary results have been obtained in nearly 50 per cent. of cases. Patients who live without recurrences in the glands or in other parts of the body for more than 18 months usually remain free from disease for long periods, and in about 30 per cent. of them cures may be expected.

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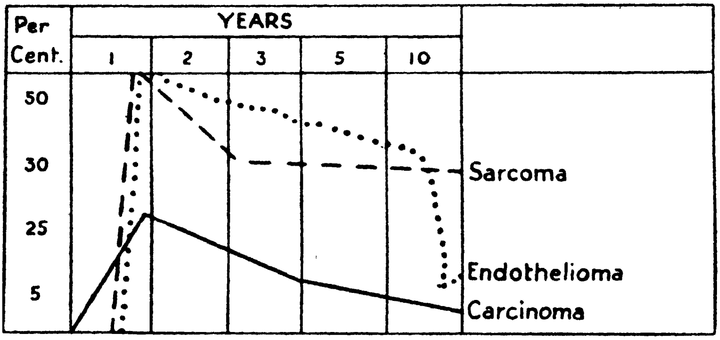
* Harmer, " Radiotherapy in Cancers of the Upper Air Passages," Semon Lecture, Nov. 1931 ; John Murray, London.

† Patterson, N., " Diathermy in Malignant Disease of the Mouth, Nose and Pharynx," *Lancet*, Sept. 1934, ii, 633.

Curves showing percentage of cures and the periods of recurrence of growths in the nose or pharynx with different types are roughly indicated in the following table:



PHARYNGEAL POUCHES

These pouches originate at the lowest part of the pharynx, opposite the back of the cricoid cartilage.* In this region there is a weak spot between the fibres of the inferior constrictor muscles through which the mucous membrane is sacculated by pressure during the act of swallowing. In many instances the walls of the pouch are very thin, though they may become thickened by inflammation. As a rule, there is a wide communication with the pharynx, so that food passes into the pouch more easily than into the œsophagus. Symptoms are often indefinite but highly suggestive and diagnosis can be made by X-ray examination. When barium is swallowed the pouch fills and then empties into the œsophagus from the top, and not from the lower end as with a stricture. Occasionally œsophagoscopy is necessary to confirm the size of the opening of the pouch and the condition of its lining membrane. Very rarely carcinoma arises in a pouch. Small pouches may give rise to so little trouble that no radical treatment is necessary, and in very old people operations should be avoided if possible.

The following operations may be employed:

Dilatation with bougies.—This method is effective for very small pouches. A large sound should be passed at regular intervals to dilate the œsophagus at or just beyond the mouth of the pouch. So long as no difficulty is experienced in the passage of the bougie there is no urgent need for any operation, but if the pouch gets larger and dysphagia increases, radical operation is called for. In many instances the size of the sac does not increase, and many patients have so little inconvenience that as soon as they realize the nature of their trouble they quite rightly decide to have no treatment at all. But there is no reason why a pouch that is giving rise to real and increasing trouble should not be dealt with surgically, provided there is no precise contra-indication. When operation is decided upon, care should be taken to get an enfeebled patient into good condition, and this may necessitate preliminary gastrostomy. A longstanding pouch should be cleaned by irrigation for some days preceding interference, and it must always be emptied just before operation.

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* Keith, *Brit. Med. Journ.*, 1910, i, 376.

Several methods of dealing with the condition may be employed.

Invagination of the sac. Bevan's operation.—General anæsthesia is usually employed but local infiltration and regional anæsthesia have the advantage that voluntary swallowing efforts may help the identification of the pouch. An incision is made on the left side of the neck along the anterior border of the sterno-mastoid, and the pouch is exposed as in lateral pharyngotomy. In all operations for pouches the incision must be of adequate length, depending not only on the size of the pouch but on the build of the patient. In big fleshy subjects the incision should extend along the anterior border of the lower two-thirds of the sterno-mastoid, whereas in spare subjects one of half that length or even less will suffice. In any case it must be centred about the level of the cricoid. In dealing with pouches of moderate size experienced surgeons, with a view to the cosmetic result, may prefer a transverse incision following one of the natural folds, but this is not recommended for general use.

After making the skin incision, the platysma and deep fascia are divided and the anterior border of the sterno-mastoid is defined. The left pretracheal muscles are drawn towards the middle line and, at a deeper level, the thyroid. The pouch will be found between the trachea internally and the common carotid sheath on the outer side. The omo-hyoid muscle can usually be retracted downwards out of the way or the pouch may be enucleated behind it, but with a big pouch the muscle may be an embarrassment and should be divided and later resutured. Some small arteries and the middle thyroid vein may have to be caught and divided. As a rule the inferior thyroid artery can be stripped aside, but in dealing with large pouches it may have to be divided. Sometimes the pouch is not easy to identify and good retraction of the sterno-mastoid, careful hæmostasis and good illumination are essential. When identification is difficult, it may be assisted by passing a rubber stomach-tube of full size down the œsophagus. Chevalier Jackson recommends that an assistant should pass an œsophagoscope into the pouch ; the illumination of this instrument shines as a dull red glow through the wall and helps to show up the pouch. To facilitate the ready introduction of the instrument, the patient should swallow a stout silk-thread guide two or three days before operation. In addition, the pouch may be gently lifted forwards into the incision by manipulating the shaft of the œsophagoscope.

As a rule, the pouch can be separated by blunt dissection, but there may be some fixation as the result of infection, and the knife or scissors may have to be used cautiously. The very large pouches may extend into the mediastinum, but they can usually be readily withdrawn, the process of enucleation being assisted by the finger. When a large pouch cannot be satisfactorily mobilized, it may be necessary to make a corresponding incision on the right side of the neck in order to assist the separation. These pouches are not only thin-walled but friable, and they should not be grasped with toothed forceps ; a ring-forceps, like a small sponge handle, is the best instrument. The position of rhe recurrent laryngeal nerve must always be borne in mind, and tough handling and the blind use of forceps are both to be avoided.

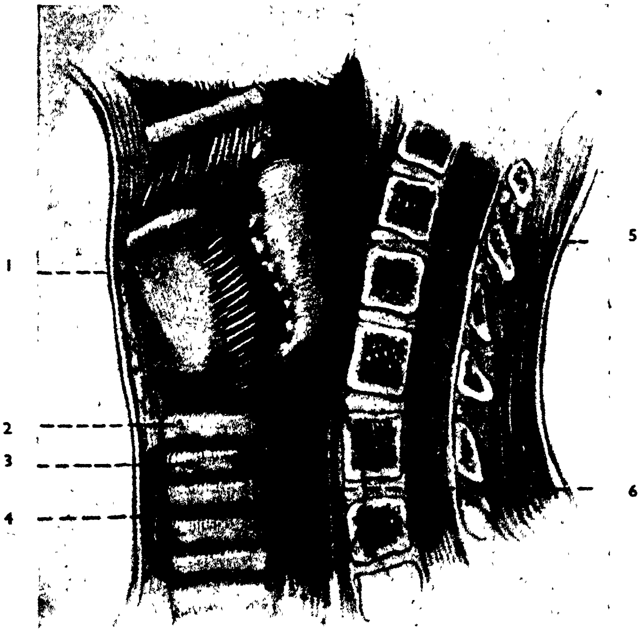

Fig. 684.—Pharyngopexy (Hill's operation).

1, Thyroid cartilage ; 2, cricoid cartilage ; 3, trachea ; 4, œsophagus ; 5, pouch sutured to superior constrictor muscle ; 6, original position of pouch.

If the sac is of small size and thin-walled it may be invaginated into the pharynx, and the fibres of the inferior constrictor brought together with interrupted catgut sutures over its base, so that the space is entirely obliterated. The invaginated part usually shrivels up and ceases to give trouble, but there have been cases of serious asphyxia following the operation.

Pharyngopexy. **Hill's operation.** (Fig. 684.)—The sac, having been exposed as before, is completely freed from the tissues at the lower part of the neck, and dragged upwards. It is essential that the pouch, including its neck, should be thoroughly isolated, so that it can be reversed without any tension or tendency to pull back into its old position. The reversed pouch is then sutured to the muscles of the lateral wall of the pharynx as high up as possible, so that its opening is directed downwards instead of upwards. Great care must be taken that the sutures do not pass through the walls of the pouch. To prevent the sac from dropping back to its original cavity at the base of the neck, six or more sutures should be inserted to fix it to the pharynx, and a second series to obliterate the space from which the sac was taken. The latter sutures should unite the fascia behind the sterno-mastoid to that which covers the lateral lobe of the thyroid gland. For pouches with fairly thick-walled sacs of moderate size, this method gives very good results and is more reliable than Bevan's operation. Either of the above operations is safe, and especially suitable in old people. If no opening is made into the sac, the risk of sepsis is very slight.

Excision.—In most cases this is the method of election. The pouch is freed and the attachment of its neck to the œsophagus is completely exposed and differentiated. If small, the neck of the sac should be ligatured. When the opening is large, it should be clamped before the sac is removed or, if this is impossible, the neck should be divided and closed by suture, a small section at a time. While the division of the neck of the pouch and the suturing is being carried out, the cellular tissue must be carefully protected against infection by gauze packing soaked in antiseptic. Two layers of sutures should always be employed, one fine and continuous to close the opening in the mucosa, and the second of interrupted sutures to bury the first by a covering of pharyngeal muscle. The tissues are soft and friable and must be gently handled. The sutures of chromicized catgut, size 3/0, should be passed with a fine, round needle and must not be drawn too tight or they cut through. Any cellular tissue in the vicinity should be laid over the closed incision and either tied in position with the long ends of some of the second row of sutures, or fixed with a separate stitch or two. Irrespective of the type of subject or the condition of the pouch, a soft rubber drain must always be brought from the depths of the wound to the surface and must not be removed sooner than four days after operation. A voluminous dressing should be applied to act as a support for the head and neck.

Swallowing in small quantities may be allowed from the first, but may be very painful for about twenty-four hours. Soft solid food should not be allowed sooner than a week after the operation. Some surgeons feed the patient through a Ryle's tube for the first four days and do not allow solids for three or four weeks. If the œsophagus has been carefully sutured, the parts usually heal without trouble, and in any event the track to the surface provided by the rubber drain is a safeguard against spread of infection towards the mediastinum. If the wound in the gullet has not been effectively sutured or if it breaks down, a fistula forms. If the whole wound does not break down as the result of infection and if the parts are kept clean, a moderate fistula tends to heal spontaneously. In other circumstances, a large fistula may form, not only with constant discharge of saliva, but with escape of everything taken by the mouth, and as a result the patient rapidly goes downhill. The proper treatment is to feed the patient by stomach tube thrice every twenty-four hours and to keep the wound as clean and dry as possible. As an aid, the patient should lie on the left side, with the foot of the bed slightly elevated. Continuous suction may also be useful. If these measures do not lead to rapid improvement, gastrostomy is indicated and some intravenous nourishment, or blood-transfusion, may be necessary. Attempts at closure by local interference are not likely to help and may make matters much worse.

This method of primary excision used to be attended with a high mortality from leaking and mediastinitis, and on that account a two-stage operation was devised and is frequently practised.

Two-stage operation (Goldmann).—The sac, having been freed, is drawn outside the wound and fixed by sutures which attach the skin and muscles all round the neck. It should be drawn as high as possible so that its mouth is directed downwards. The greatest care must be taken not to puncture the pouch near the neck. If the patient is very weak from want of nourishment, the fundus may be punctured after closure of the wound, and a small rubber catheter inserted several inches into the gullet for feeding, secured by a circular ligature. Ten days later the neck of the pouch will be firmly adherent to the surrounding tissues and its superficial part can be clipped away with scissors or excised with the diathermy needle without any anæsthetic. The mucosa and skin margins are turned in and united accurately by two layers of sutures. Even if it cannot be accurately sutured, the cut surface soon retracts and closes. The remaining wound usually heals quickly and without fistula. At the second stage some surgeons carry out a submucous resection of the sac, ligature it off, and suture the outer walls. These operations are safe, and applicable to cases in which the sacs are large enough to be brought to the surface without tension. Surgeons who have not had great experience of these cases should adopt this method whenever possible, and so avoid the dreaded complication of sepsis and mediastinitis.

Frank H. Lahey* advocates operation even for very small diverticula if associated with symptoms. In these cases the sac is too small to be brought up to the skin surface, and at the first operation it is thoroughly separated and displaced upwards, i.e. so that the mouth points downwards, and is fixed to the prethyroid muscle with sutures of fine black silk. The wound is then closed with a cigarette drain down to the sac. Ten days later the wound is re-opened and the black silk acts as a guide to the sac, which can readily be re-separated and removed, while under gentle traction the muscle about the neck is incised down to but not into the mucous membrane. The latter then forms a sort of pedicle which is ligatured with chromic gut, and the sac is cut away. The stump of ligatured mucous membrane retracts into the muscle-sheath. A drain is brought from the neighbourhood of the stump and the incision is sutured. As the cellular planes have become sealed between the first and second stages, there is very little risk of infection. A small fistula occasionally results, but heals readily.

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* *Surg. Gyn. Obstet.*, Feb., 1933, lvi, 187, and *Journ. Amer. Med. Assoc.*, Oct. 30, 1937, cix, 1414.

After any method of operation the patient may complain of slight difficulty in swallowing and this may be the result of narrowing at the site from which the pouch originated. As a rule, the trouble soon disappears, but it may be necessary to pass a bougie at increasing intervals for as long as a year after operation.

Results.—In 1937 Lahey (*loc. cit.*) reported on 82 cases with only one death and that in a man of eighty-five. He gives the after-history of 53 of these cases operated upon over two years with the following results : 2 failures (i.e. recurrences), 2 poor results, and 49 good results.

Gastrostomy.—This treatment should be reserved for patients who are so old and feeble that they are not considered strong enough for operations on the sacs. It should only be performed if they are unable to swallow with comfort enough fluids or soft food for adequate nourishment. On the other hand, it may be most valuable as a preliminary to the radical operation rather than an alternative, and at any subsequent time excision of the pouch can be carried out if the general condition permits.

CHAPTER XXXI

OPERATIONS ON THE LARYNX AND TRACHEA

By H. G. BEDFORD RUSSELL

LARYNGEAL OPERATIONS BY INDIRECT LARYNGOSCOPY

LARYNGEAL conditions can be approached surgically either *via* the mouth or *via* incisions in the neck, there being now very general agreement on the indications for the route.

Until the introduction of direct-vision laryngoscopy the oral route was only suitable for the relief of conditions involving very little tissue, the treatment of which would not be likely to cause much bleeding or much distress to the patient under local anæsthesia. Killian's direct-vision method greatly increases the sphere of usefulness of operations carried out *via* the mouth, and is almost equally suitable for general or for local anæsthesia. A description of this method will be found on p. 1469.

Indirect laryngoscopy is suitable for the application of caustics or of the electro-cautery to granulations; also for the removal of small innocent tumours, of which the commonest are the small cystic swellings on the edges of the vocal cords usually known as fibromata. Papillomata are still occasionally removed by this method; but, as they are now believed to be infective, it is not surprising that they recur frequently. A case is on record in which 200 operations were performed.

Other procedures suitable for this technique are operations upon cysts of the epiglottis, scarifications of œdematous mucosa carried out with a guarded knife, curettage of tuberculous ulcers, and removal of foreign bodies which are not too large or too firmly impacted.

The operator wears either a forehead-lamp or a laryngeal reflecting-mirror, and directs a beam of parallel or converging rays on to a warmed, concave mirror about $\frac{3}{4}$ in. in diameter, held firmly upwards and backwards against the patient's soft palate by the surgeon's left hand. The tongue, grasped in a handkerchief, is held, fully protruded, in the right hand of the patient, who is told to breathe silently and slowly through the widely opened mouth.

The appropriate sprays, probes and other instruments are many, but have this in common: they all have an approximately right-angled curve, the distal limb being about two inches in length and the proximal limb about eight inches. A malleable probe has great advantages.

Operation.—The larynx is sprayed with equal parts of 10 per cent. cocaine hydrochloride and 1 in 1,000 adrenalin, and when somewhat numbed is painted in the required region with a firmly held pledget of wool moistened with adrenalin 1 in 1,000 and dipped sparingly into crystals of cocaine hydrochloride so that they dissolve. When removing an intralaryngeal growth, the surgeon sits facing the patient. The mouth is opened to the fullest extent, the tongue drawn well forward and held by the patient's own right hand, and the mirror introduced. If the epiglottis overhangs, it can be drawn forward with forceps ; in rare instances, its upper margin has to be transfixed and retracted with a thread; the latter being grasped and kept taut by the weight of a pair of pressure-forceps allowed to hang freely.

The laryngeal forceps is warmed, and taken in the right hand when the tumour is on the right side of the larynx, and in the left hand when the tumour is on the left. Introduction is difficult, and no description, however minute, will obviate the necessity for oft-repeated attempts. Suffice it to say that, guided by the reversed image in the mirror, the operator avoids contact with any part of the fauces and pharynx until the growth is reached.

When the point of the instrument is seen to rest upon the growth, the blades are opened, and the tumour is grasped and avulsed ; with careful manipulation there is little danger of wounding the normal mucosa, and hæmorrhage is insignificant. If there are multiple growths the patient must understand that it may be necessary to repeat the operation either immediately or after an interval. Given suitable instruments, sufficient experience and a tolerant patient, it is possible with the help of cocaine to remove the majority of small tumours.

After-treatment.—The most important aspects of the after-treatment should have received attention beforehand. Many laryngeal troubles are merely results of infective processes in the upper or lower respiratory tracts, and treatment of the larynx alone—as for example the cauterization of tuberculous granulations without treatment of the lungs—is foredoomed to failure.

If the accessory nasal sinuses, teeth and tonsils have been rendered healthy beforehand, laryngeal wounds will be found easy to treat. *Vocal rest and prevention of coughing* are imperative ; and to this end the larynx may be sprayed four-hourly with a solution containing equal parts of 10 per cent. cocaine hydrochloride and 1 in 1,000. adenalin. The patient is given ice to suck or lozenges of cocaine and krameria, and cold compresses are applied externally. Inhalations of menthol or of the various balsams may be acceptable ; while syrup of Virginian prune and small doses of codeine are useful as general measures in the prevention of cough.

Radium introduction.—Indirect vision has also been employed with some success for the introduction of radium in the treatment of laryngeal papillomata. The patient has to be educated up to a suitable degree of tolerance, and the radium introduced upon a malleable silver holder which is bent so that upward movement is prevented by the hard palate. Downward movement is prevented by winding the wire round the face and head, and the patient's head is steadied with sand-bags. In the earlier cases, 50 mg. of radium with a filtration of 0·5 mm. of platinum-iridium were thus held between the cords for periods up to two hours. A mild perichondritis of the larynx followed this treatment upon one occasion, but this complication may be avoided by using a 0·6 mm. filter. The results obtained are very encouraging (there having been in one case a freedom from recurrence for seven years), and there is apparently no damage to the vocal cords.

TRACHEAL OPERATIONS

TRACHEOTOMY

The word tracheotomy is often associated in the mind of the student with a mental picture of rapid slashes of the knife at the throat of a deeply cyanosed child. It happens, of course, in rare instances, that the operation has to be performed under very unfavourable conditions ; but in the vast majority of cases the conditions necessitating this step are progressive, and the indications are evident early enough to permit a deliberate operation. The need for uncomfortable speed in other cases may be largely discounted beforehand by careful routine. For instance, no operation upon the respiratory tract should be undertaken unless a tracheotomy set or intubation set is ready at hand, and the equipment of every laryngologist and anæsthetist should comprise the necessary instruments.

Indication.—The indication for tracheotomy is obstructed respiration, and in a large number of conditions the indication may arise somewhat suddenly.

(1) *Diphtheria* offers the widest sphere of usefulness : about 1 per cent. of cases are likely to require operation (*see* Table on p. 1448).

(2) *Acute laryngitis* with œdema, as the result of sepsis, trauma, inhalation of irritating gases, chemicals, or steam ; in acute specific diseases other than diphtheria ; in the course of renal or cardiac disease ; or as the result of excessive indulgence in spirits, or overdoses of drugs such as potassium iodide ; or in allergic subjects.

(3) *Dyspnœa,* arising during surgical operation or at other times from the inhalation of foreign bodies.

(4) *Fracture of cricoid and thyroid cartilages or hyoid bone* with œdema, and perhaps surgical emphysema, may suddenly produce obstruction.

The other conditions requiring tracheotomy for the most part give ample warning.

(5) *As a preliminary to operation* likely to cause immediate or delayed respiratory obstruction, as, for example, removal of the upper jaw, or diathermy of a growth at the base of the tongue ; or to facilitate endotracheal and endobronchial manœuvres.

(6) In some cases of *cut throat or gunshot wound involving the air-passages,* where blood may enter the trachea.

(7) *Compression of the trachea* from without by swellings in the neck or mediastina which are not removable by operation. Examples of these are swellings of the thyroid and thymus-glands, aneurysms, and growths.

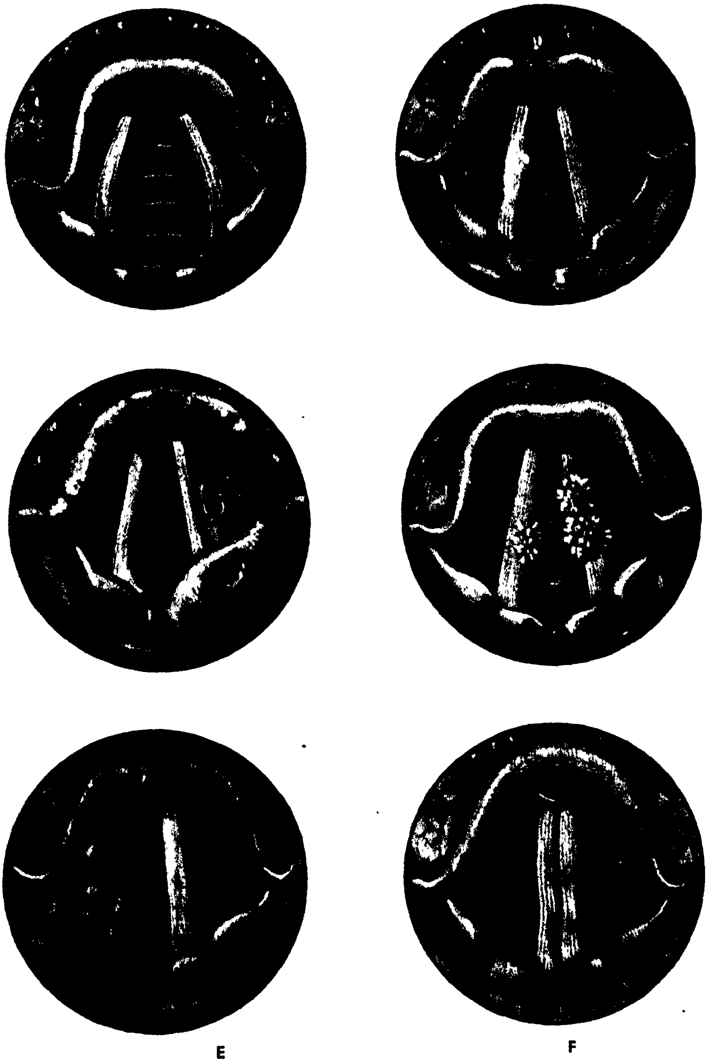

Fig. 685.—Tumours, etc., of the larynx.

A, The larynx in inspiration ; B, fibroma ; C, tubercle ; D, papillomata ; E, extrinsic epithelioma F, bilateral abductor paralysis.

(8) *Obstruction by tumours* of the larynx or trachea, as papillomata and carcinomata of the larynx, or by impacted foreign bodies. (Fig. 685.)

(9) *Bilateral abductor paralysis* resulting from the various forms of toxic neuritis, syphilis, diphtheria, tabes. (Fig. 685, F.)

(10) *Laryngeal spasm* may necessitate tracheotomy to save a failing heart; or to aid artificial respiration during chloroform induction.

(11) *Congenital laryngeal stridor, congenital webs of the air-passages, epilepsy,* and *ankylosis of the crico-arytenoid joints* are rare conditions occasionally calling for tracheotomy.

(12) *Tertiary syphilis,* acquired or congenital, may cause obstruction by the swelling accompanying perichondritis of the laryngeal cartilages; and tracheotomy has occasionally been found necessary in tuberculous disease of the larynx.

The classical symptoms given as calling for tracheotomy, namely, recession of the chest, working alæ nasi, laryngeal excursion and weak pulse, should not be allowed time to develop. Their presence leads to inability to take nourishment, further weakness, and so to a vicious circle of deficient aeration, more toxæmia, and weaker heart.

Surgical anatomy.—There is a considerable difference between the conditions in the tracheotomy triangle in adults and in children.

In children the neck is relatively shorter, and so the larynx appears higher. The trachea does not leave the surface so rapidly from above downwards as it does in adults, which makes it somewhat easier of access, but on the other hand the laryngeal cartilages and the trachea are softer, and very difficult to distinguish if there is congestion of the cervical veins. The trachea is more mobile than in adults, and so is easier to miss if the head be rotated ever so slightly from the mid-position. In children, again, the jugular veins are relatively larger, and the left innominate vein may be higher in the neck. The thyroid isthmus is relatively broader and higher up, while the thymus may in rare cases extend into the neck, so as to lie in contact with the isthmus.

The trachea varies in diameter at different ages, being 4 mm. at 6 months, 7 mm. at 2 years, 10 mm. at 4 years, 12 mm. at 10 years, and 29 mm. at 20 years. Its length is 4½ in. at maturity, and there are only 2½ in. available above the suprasternal notch for operative purposes. This can be slightly increased by extending the head, which also lessens the distance from the surface.

Even in an obese adult the hyoid bone and the thyroid cartilage can usually be palpated, but it is not always easy in children to define the lower border of the cricoid cartilage, the upper limit of the trachea.

The *pretracheal fascia* is firmly attached to the cricoid cartilage above, and passes down in front of the trachea, splitting to enclose the thyroid isthmus as it overlies the 2nd, 3rd and 4th cartilaginous rings. Then, going deeper, it passes behind the sternum and blends with the fibrous pericardium. Hence the grave risk attending local infection, which, if deep to this fascia, tends to track down to the mediastinum.

Veins are important. The left innominate may cross the trachea obliquely as much as ½ in. above the suprasternal notch, and is liable to injury. The inferior thyroid veins run down vertically from the lower border of the isthmus. Provided the incision is placed mesially, the anterior jugular veins running downwards in the superficial fascia should not be injured.

Arteries do not usually give trouble. The thyroid isthmus is partially supplied by anastomotic branches of the superior thyroid artery; there is usually a branch of supply from the inferior thyroid artery. Rarely the thyroidea ima branch of the innominate passes upward in front of the trachea.

Instruments.—Small scalpel, two pairs of toothed dissecting-forceps, four fine-pointed pressure-forceps, two double-hook retractors, one sharp and one blunt hook, aneurysm-needle, scissors, needles, tracheotomy dilator, tubes and tapes, and an intratracheal catheter should be available. The tubes should be provided with a movable shield which lies flush with the neck. For general use the tubes of Jackson and Durham are most serviceable, and an introducer is desirable.

Preliminary considerations.—Where time permits, tracheotomy should be performed in an operating theatre with every appurtenance likely to facilitate the procedure.

For a child, a large towel should securely envelop the body, arms, and legs, so that one assistant suffices to control the movements of parts other than the head.

A pillow should be placed under the shoulders, so that the head can be hyperextended and supported exactly in the midline by a second assistant, while a third helps with the operation.

An *anæsthetic* is not essential. But in children, provided the pulse be strong, anæsthesia is desirable, as breathing is often less laboured after induction is complete, and consequently movement and bleeding should diminish.

In adults local anæsthesia is satisfactory. St. Clair Thomson, in non-diphtheritic cases, injected a few minims of a 2½-per-cent. solution of cocaine into the trachea three minutes before opening it, thus avoiding the burst of coughing which otherwise usually follows.

In operating on children the proper use of the sharp hook is most important. As soon as the incision has been made, it should be thrust into or beneath the lower border of the cricoid or the thyroid isthmus or the trachea, strictly in the middle line, and securely held by an assistant. It must not be removed until the tube is safely in position. Its use is (1) to mark the midline; (2) to steady the trachea; and (3) to draw the trachea nearer to the surface.

Tracheotomy is facilitated by the preliminary passage of an intratracheal catheter, and surgeons should familiarize themselves with this procedure, which is usually reserved for the administration of anæsthetics (*see* p. 37, Vol. I).

Operation. (1) **Crico-tracheotomy** (section through the cricoid cartilage).—This, though sometimes performed in emergency, should never be planned; and if done should be changed into a lower tracheotomy at the first opportunity.

(2) **Infra-cricoid tracheotomy.**—Davis* has introduced a simple

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* *Pract.*, 1933, cxxi, 361.

operation which may well take the place of laryngotomy for the relief of laryngeal obstruction of great urgency. The nail of the left index finger is placed at the lower border of the cricoid cartilage, and a scalpel with the blade turned transversely is inserted horizontally into the trachea above the first ring and twisted a little so as to permit air entry. A Butlin's laryngotomy tube is now inserted in place of the knife.

(3) **High tracheotomy** (section above the isthmus).—This is the operation of choice in children with acute laryngeal obstruction, and in adults may occasionally be necessary in obese short-necked individuals, or where a growth embraces the lower part of the cervical trachea. In cases of extreme urgency it is undoubtedly the easiest tracheotomy, but it is open, though in a lesser degree, to the criticisms applicable to crico-tracheotomy and, wherever possible, a low tracheotomy should be substituted if the obstruction is to persist.

The surgeon stands at the right side of the head. The landmark of the pomum Adami having been recognized by palpation, the cricoid cartilage is sought for and gripped between the left thumb and forefinger, and from its lower border a median vertical incision 1½ in. long is made downwards towards the sternum. In young children, in whom the cricoid is difficult to locate, the incision should be made in such a position that its lower end reaches almost to the sternum, thus avoiding the mistake made by beginners of placing the cut too high over the larynx. The skin and subcutaneous fat are divided between the anterior jugular veins, and the bleeding is controlled by forceps. The sterno-hyoid muscles are exposed, and the interval between them is opened up by dividing the anterior layer of deep cervical fascia. These muscles and the sterno-thyroids beneath them are separated for at least an inch, and may be retracted, if the muscles alone are included and the retraction is equal on both sides. Keeping still in the middle line, and steadying the trachea, the surgeon now divides the fascia covering the tube, and exposes the front of the cricoid, and below it the vascular isthmus of the thyroid gland. The landmark required at this stage is the cricoid, and along it a small transverse cut should be made through the pretracheal fascia, under which the handle of the scalpel can be introduced, the isthmus with its fascial covering being stripped downwards towards the lower part of the wound, where it is held by a blunt hook. The surgeon can now see or feel with his finger the upper rings of the trachea, and the retractors should be reintroduced so that it is thoroughly exposed.

It is advisable to seize all bleeding-points and to ligature the vessels at this stage, if the patient's condition is satisfactory. While the trachea is being opened, the movements of the larynx should be controlled by grasping the cricoid with the finger and thumb of the left hand. The scalpel should be held with the edge upwards and stabbed gently into the trachea to ensure division of the mucous membrane with the outer coats of the tube. The incision must be precisely in the middle line, and must be made with restraint, for fear of puncturing the œsophagus. In adults the tracheal rings may be ossified, and section with a scalpel impossible. If there is urgency, the knife should be introduced transversely between the rings, and the rings separated. Otherwise small bone-shears can be used. The opening should be circular, dividing not more than two rings, so that as far as possible it is completely blocked by the cannula which is introduced. This, in a large measure, prevents the escape of septic material into the mediastinum. If the dyspnœa is severe, there is a sudden rush of air out of the lungs as the tracheal wall is penetrated. The dilator is introduced, and the anæsthetic abandoned. Temporary apnœa often follows the first inspiration, but the colour improves, and after an interval coughing commences ; mucus, pus, or membrane is expelled, often in large amount, and deeper inspiration and expansion of the chest follow. If necessary, oxygen should be given to improve the respiration.

As soon as breathing is regular, a cannula of suitable size should be quickly inserted. This rarely presents any difficulties if the opening is well dilated and an introducer employed. It is easier if the divided ends of the cartilages are excised, so that a circular opening is produced, as recommended by Trotter. This method has the great advantage that the tube can be easily changed. The tube must sit well, without tilting, and must be fixed by tying the tapes firmly round the neck. Having been cleared of blood, the wound should be moistened with 5 per cent. sulphonamide solution, or, if there is time, this should be applied before opening up the trachea. A thin layer of glycerin-gauze is cut half across and slipped under the shield so as to embrace the tube. The inner tube is changed frequently.

(4) **Median tracheotomy** (section through the isthmus of the thyroid gland).—The incision through the skin and superficial fascia should be rather longer than in the high operation. The infrahyoid muscles are separated as before. The isthmus is exposed, and in a child can be cut through boldly in the middle line, bleeding-points being seized before the trachea is opened. In adults, when there is no urgency, it is better to ligature the isthmus in two places, either by passing a threaded aneurysm-needle under it, or by clamping it with forceps, leaving a space of ½ in. in which the isthmus can be divided. The trachea is thus exposed, and can be opened as before. Trotter has pointed out that this type of operation has the advantage that, should the tube be removed, there is no difficulty in re-introducing it. In both high and low tracheotomy the isthmus is pulled out of its normal position, and tends to spring back on removal of the tube, partly covering the tracheal incision.

(5) **Low tracheotomy** (section below the isthmus).—A long incision is needed, and should extend down to the suprasternal notch. (Fig. 686.) In dividing the fasciæ, which are thick and loose near the sternum, there must be no "tailing" of the skin wound. The isthmus must be exposed by separating the infrahyoid muscles, and

its lower border determined and dragged upwards by a blunt retractor. It will be noticed that the trachea is more deeply placed than in high tracheotomy, and it is important to remember that it is more difficult to expose, owing to the numerous veins that lie in front of it. Deep cutting is therefore dangerous. The trachea must be exposed by deliberate dissection. Bleeding-points must be seized and the trachea thoroughly exposed before it is opened. A long tube will be needed, for preference with an adjustable shield, as in Durham's instrument. I perform a low tracheotomy where possible, but divide the thyroid isthmus instead of retracting it.

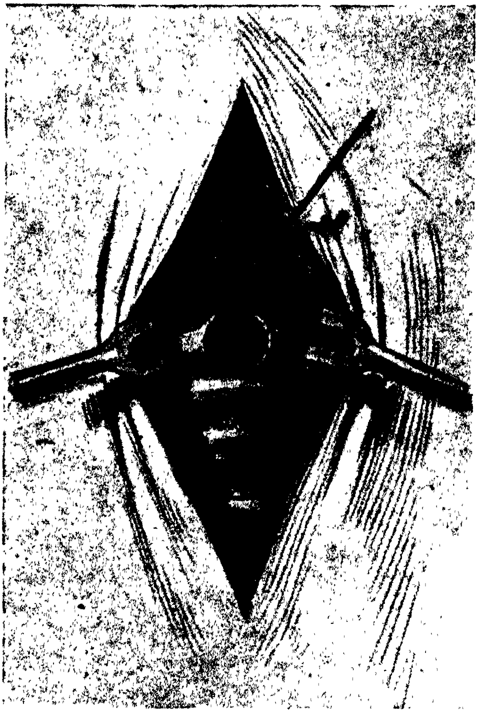

Fig. 686.—Low tracheotomy : a small segment of a tracheal ring has been resected.

Tracheotomy becomes difficult if any of the çardinal rules are transgressed. To reiterate: The head must not be allowed to rotate at all, and the incision must be truly mesial. Extension of the head is helpful, provided that congestion of the cervical veins is not thereby rendered more severe. The pomum Adami can always be found, and if the trachea is missed, this prominence can be exposed and the cricoid and trachea followed down therefrom. The greatest difficulty is likely to be due to hæmorrhage from veins. This can be avoided, and struggling diminished, by a timely decision to operate ; indeed, this is the solution of nearly all the usual difficulties, both during and after the operation. Blood must not be allowed to enter the trachea. If suction is available it is helpful in preventing this ; if not, the head may have to be lowered after the trachea has been opened and dilators introduced. Venous bleeding will stop as soon as respiration becomes free.

Failure to breathe after an opening has been made in the trachea is due to obstruction, or to collapse. In these circumstances the trachea should be opened widely, and a pair of forceps or a sucker passed down to the bifurcation to dislodge any obstruction and to promote coughing. It is useless to employ artificial respiration unless the obstruction has been removed. Collapse should be treated by compressing the limbs with Esmarch's bandages, by lowering the head, and by warmth, and artificial respiration should be continued. In cases of great emergency a rapid operation without anæsthetic is forced upon the surgeon. The larynx is gripped by the left thumb and finger and held firmly, while a long incision is made downwards from the cricoid and deepened, with total disregard of bleeding, until the trachea is reached. The trachea is stabbed in the midline, and the blade rotated through a right angle. This will permit one breath, after which the dilators are guided into the opening with the help of the left forefinger. The patient is then drawn over the end of the table so that the head hangs downwards. The bleeding soon ceases.

After-treatment.—Dilators should be kept handy, and an experienced person must be at the bedside as long as there is any membrane, bloodclot or discharge in any quantity. A return of dyspnœa points to the need for removing and cleansing the inner tube. Should this fail, the trouble is probably due to the tube having slipped out. Its replacement is facilitated by a good light and the use of an introducer. A warm, airy room, with steam inhalations, is advisable. In septic cases inhalations of benzoin or menthol are indicated. Feeding is difficult, and may have to be done through a nasal tube. The cannula should be removed as soon as the secretions become small in amount and serous rather than purulent. In diphtheria the period varies from five to fifteen days, after which the case must be regarded as one of " retained tube." It is a good plan to replace the metal tube by a rubber one three or four days after the operation and to dispense with the latter as soon as possible. If the child is unable to breathe with the tube corked, stenosis of the larynx should be suspected, and a laryngoscopic examination made. Sometimes the difficulty is merely functional, and can be overcome by re-education.

Complications.—*Hæmorrhage*, reactionary or secondary, is likely to lead to urgent dyspnœa, from inhalation of clot. The former is unlikely in patients operated upon by those accustomed to deal with such cases. Secondary hæmorrhage is usually fatal but luckily rare. Kocher could only find 87 cases in the literature, and in 56 of these the bleeding was from the innominate artery. This is an argument against low tracheotomy but, since the general use of antitoxin and the omission of any sutures below the tube (Jackson), wound infection has become uncommon and the incidence of secondary hæmorrhage has much diminished.

Ulceration.—Ulceration of the mucosa may be due to pressure of the tube owing to a too high tracheotomy or to want of care in seeing that the tube sits nicely. It is a serious complication. Besides leading to retained tube, there is grave risk of stenosis if it is allowed to persist for any time. A lower tracheotomy may be necessary to remove the irritation of the tube from the ulcer, but in milder cases it suffices to replace the metal by a rubber tube and to treat the ulcerated area by caustics.

Paralysis.—Retained tube may also be due to abductor paralysis of the vocal cords, and this may sometimes persist. Cardiac paralysis is rare, but paralysis of the soft palate is often seen. Sensory paralyses are less easily recognized, and are of less urgent importance unless the cough-reflex is impaired.

Bronchitis and broncho-pneumonia are common and seriously prejudice the prognosis.

Among the less important complications, emphysema of the tissues about the wound is common ; unless it extends to the mediastinum it is not likely to do harm.

Prognosis.—It is difficult by giving percentages to form an accurate picture of the risks of this operation. Of the deaths occurring after tracheotomy, there are very few that would not have occurred had the operation not been performed. The deaths rightly attributable to the operation are those due to hæmorrhage and sepsis. More often, death is due to a tardy decision on the part of the medical attendant to carry out the operation. This is especially so in young children with diphtheria, the patient's heart being so rapidly exhausted.

Table showing the incidence and mortality of Tracheotomy as compared with Intubation performed upon cases of Diphtheria in the Infectious Diseases Hospitals of the London County Council during the years 1932–35.*

Total cases of Diphtheria	Tracheotomies	Deaths	Intubations	Deaths
29,337	318	98	10	

It must be realized that death is usually due to the results of the disease rather than to an operation which in a healthy person might almost be considered trifling, and which is not attended by noticeable shock. Thus, the mortality in other infective diseases, such as erysipelas, smallpox, typhoid, whooping-cough and influenza, treated by tracheotomy, is very high (74.3 per cent.), owing to the severity of the toxæmia. The mortality from this operation before the days of diphtheria antitoxin used to be over 70 per cent.

The age of the patient is important : in children under one year of age only one in three recovers. The death-rate decreases gradually between the ages of one and six years.

Intubation

Until shortly before the last war, " intubation " of the larynx referred merely to the intubation employed in diphtheria. But there are two other distinct types of intubation now in use which merit detailed description : firstly, the form which has been evolved from anæsthetic practice ; and secondly, the prolonged intubation designed to overcome stenosis caused by scar-tissue.

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* Figures obtained by courtesy of the Medical Officer of Health for the L.C.C.

1. **Intubation in diphtheria.**—This has a definite place in the milder cases where antitoxin has been given early. But in most fever hospitals the recognition of the safety of tracheotomy, when carried out early enough, has relegated intubation to a less important place.

Instruments.—A gag for opening the mouth ; a set of short, light tubes of vulcanite or light metal, with a gauge showing the sizes for different ages, an instrument for intubation and extubation, and equipment for tracheotomy.

Two assistants are necessary, one to hold the patient, the other to control the head and the gag.

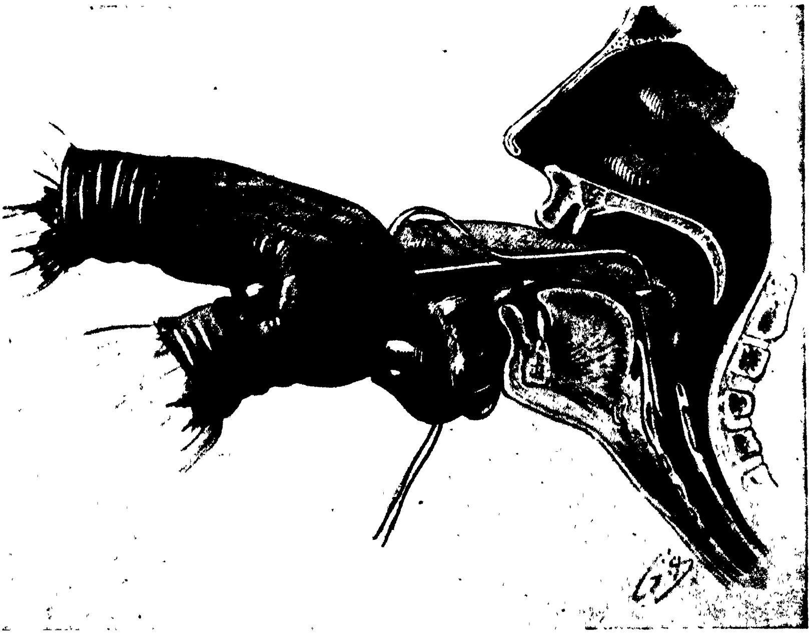

Fig. 687.—Intubation.

Operation.—Anæsthesia is not required, even for children, as movements can be controlled by wrapping the patient in a large towel or blanket with the arms extended by the sides. One assistant holds the child, either sitting up or lying on the back with the head extended over the table. A tube is chosen in accordance with the patient's age, threaded and mounted upon a Thorner's introducer, and the mouth gagged widely open. The head being extended, the surgeon passes the left index-finger over the back of the tongue and behind the epiglottis. The landmark required is the cricoid cartilage. As soon as this is felt, the finger is drawn forward so as to hook up the epiglottis, and the introducer and the tube are rapidly passed over it. The handle of the introducer must be raised as high as possible, so as to throw the point of the tube against the back of the epiglottis. The instrument is boldly lowered, thus passing the tube through the larynx until its collar rests firmly upon the ventricular bands. It should be held in place with the left index-finger, while the introducer is removed. The operation should take from three to five seconds, and should be performed without force. (Fig. 687.)

Failure to find the opening is generally due to not keeping the instrument in the middle line, or to the use of too large a tube. Too small a tube is at once coughed out. The tube, though properly passed, may push membrane in front of it, or may be blocked by membrane, in which case tracheotomy is indicated. The tube may pass into the œsophagus and may increase the dyspnœa by pressing on the back of the larynx ; or the tube with its thread may slip through the gullet into the stomach. This is not a serious accident, as the tube will be passed per rectum or, more rarely, vomited. Frequent expulsion of the tube by coughing, or urgent dyspnœa, is an indication for tracheotomy.

After-treatment.—A tracheotomy set and intubation instruments must be kept by the bed, and someone competent to do intubation or tracheotomy must be at hand, in case the tube is coughed out and the dyspnœa recurs. There is usually an interval of at least twenty minutes before dyspnœa becomes urgent. Blocked tubes are more dangerous, but are generally expelled unless the child is weak. If a thread is left the nurse can extract the tube, but care must be taken that the child does not pull it out. Swallowing may be difficult, and liquids passing through the tube may cause coughing. Tracheotomy should be performed if the child urgently needs nourishment.

Changing the tube.—The tube should be left *in situ* for forty-eight hours, and then changed daily, aiming always at removal as early as possible, but this will probably not be before the fifth day.

Complications.—Intubation in diphtheria is not invariably free from dangers, immediate and remote, apart altogether from failure to relieve the obstruction. There may be injury to the larynx, with resulting hæmorrhage, emphysema, or abscess ; and even false passages are not uncommon. The pressure of the tube may lead to ulceration associated with increase of the obstruction, and to œdema or granulations, or, more remotely, to cicatricial stenosis. Jacobson describes a type of stenosis following intubation other than that caused by trauma, the obstruction being due to paralysis of the cords. This may help to explain the frequency of retained tube after intubation.

It is claimed that intubation has the following notable advantages over tracheotomy in diphtheria : The knife is not used, and there is no skin-wound to deal with afterwards ; and the absence of cutting and of the need for an anæsthetic makes it easy to obtain the consent of relatives. Introduction of the tube requires very little time, and the tube is more easily worn than in tracheotomy. The upper air-passages are not starved of the air necessary for their proper ventilation, and the results are better in children under 5 years (the group in which there is such a notable mortality with tracheotomy). On the other hand, the dexterity necessary for intubation with the speed required by the interference with respiration is only obtainable under the conditions met with at fever hospitals ; and even in the most favourable surroundings failure is not infrequent.

Goodall finds that 28 per cent. of the tubes are coughed up, and 12 per cent. blocked. The tube often interferes with deglutition, while its lumen, though just adequate for breathing, does not permit free expectoration. Its greatest condemnation is that the outfit must comprise a tracheotomy set—for one-third of all cases need secondary tracheotomy. Further, this fact evidently calls for the constant presence of the medical man, even after a successful introduction of the tube. A comparison of the results at hospitals using tracheotomy with those where intubation was preferred shows that mortality was noticeably less with tracheotomy.

2. **Intubation for non-diphtheritic obstructions.**—Whereas it used to be taken for granted that the natural intolerance of the larynx made prolonged intubation impracticable except in fever hospitals, a growing familiarity with endotracheal work has shown that a gum-elastic catheter may be tolerated in the larynx for a surprisingly long time without harm (in one case, at St. Bartholomew's Hospital, for fourteen days). At the Cancer Hospital it is the practice to leave catheters in the trachea of patients suffering from laryngeal carcinomata for as long as forty-eight hours, the throat being sprayed four-hourly with cocaine.

It is possible* to intubate the trachea *via* the nose without the assistance of vision ; and this useful manœuvre may under certain conditions obviate tracheotomy.

Two forms of tube are suitable, either a gum-elastic catheter, or a piece of rubber tubing with the leading end cut obliquely to a point ; both require thorough lubrication with vaseline. Success in passing the catheter depends on the shape of the curve rather than the skill of the operator. By practice upon the cadaver this is found to be somewhat like a capital C, the curve being maintained by a stylet. I have used this manœuvre successfully as an emergency without previous training, and can emphasize its simplicity. It certainly requires much less skill than a tracheotomy, and can, if urgency dictates, be attempted by an assistant while the surgeon begins the tracheotomy, to prevent possible loss of time. It can also be done under *local* anæsthesia. This has been of particular advantage in the treatment of laryngeal growths by X-rays ; the tube is worn during the swelling of the growth sometimes met with during the earlier days of treatment, and is removed when the shrinkage has restored a safe airway.

Intubation of the larynx *via* the mouth by gum-elastic catheter, under the guidance of vision through a laryngeal spatula, has also been useful in my experience as a preliminary to tracheotomy in an urgent case of tracheal obstruction, due to a large vascular thyroid growth which rendered successful tracheotomy problematical. Artificial respiration was done through the airway thus supplied until the patient was somewhat restored, after which tracheotomy was performed unhurriedly and without the bleeding usually associated with respiratory obstruction. A suitably-shaped catheter and a laryngeal spatula should be available in operating theatres and in the laryngologist's bag, as well as a tracheotomy set.

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* I. W. Magill, *Proc. Roy. Soc.*, Dec., 1928, xxii, 183.

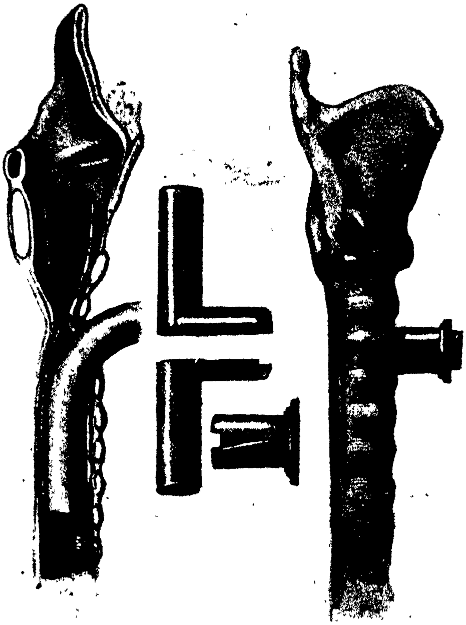

Fig. 688.—Stenosis treated by intubation.

The left-hand figure shows Harmer's method of obtaining an elastic dilating pressure within the stricture, while ensuring a patent airway. A metal cannula passes into the trachea through a fenestra in the anterior aspect of a rubber tube which occupies the lumen of the stricture. The remaining figures illustrate the use of a three-piece metal tube for intubation.

Harmer has tried, with considerable success, a method of treating stenosis of the larynx which depends on gradual dilatation of the stricture by elastic pressure. (Fig. 688.) A strong silk thread is passed *via* the mouth through the stricture, and is then brought out through the tracheotomy wound. With the help of this thread a large rubber tube is introduced into the larynx through the tracheotomy incision, and is manœuvred into position in the grip of the stricture, by alternately pulling from above and gently pushing from below. It may not be possible to get it right through the stricture at the first attempt.

A fenestra is made on the anterior aspect of the rubber tube opposite the tracheotomy wound, and through this an ordinary tracheotomy tube is introduced, so that its lower end projects beyond the rubber tube into the trachea. The length of that part of the rubber tube above the fenestra determines the degree to which it presses into the stricture; and this length is gradually increased from week to week. Ultimately it is pulled up so that it lies wholly in the stricture, and can, after some weeks or months, be replaced by a slightly larger size, and so on, until patency is restored.

The advantages of this method are that the pressure which is applied, being elastic, is not sufficient to cause anæmia of the mucosa, and so ulceration is not produced.

I have successfully varied this method of dilatation of the larynx with an ordinary rubber tube.* A loop of silk is worn in the larynx, the ends of which project from the mouth and from the tracheotomy. The patient himself carries out the dilatation, pulling through the stricture, firstly, a very fine calibre rubber catheter, and then gradually increasing sizes of catheter until the size of a stomach-tube has been achieved. Each size has to be worn for about a month, and the dilatation is found to be permanent after about eighteen months.

TRACHEO-FISSURE

Tracheo-fissure is most often used for the relief of stenosis of the trachea resulting from inflammatory conditions such as diphtheria, syphilis, foreign bodies, gunshot wound, cut throat and inhalation of irritants. It has been not infrequently employed, chiefly in America, to obtain access to endotracheal tumours. Thiesen† collected 135 cases, of which 89 were innocent growths, such as papilloma, fibroma, and masses of misplaced thyroid tissue.

The operation is really an extensive tracheotomy. The incision should be boldly extended until an adequate view of the endotracheal condition is obtained. It is sometimes possible to cure cicatricial stenosis by inserting a small cannula at the operation, and subsequently dilating the stricture with tubes gradually increasing in size.

If dilatation fails, it may be possible to excise the scar tissue, and to obtain gradual epithelization of the lumen around the cannula, normal function being ultimately restored. For tumours, an insufflation catheter is passed into the trachea below the growth, and tamponned off before the tumour is excised. Bleeding is controlled by electric cautery after free removal of the growth; and a tracheotomy cannula is inserted and left *in situ* for several days. Von Bruns‡ has obtained cures in four cases of intratracheal thyroid tumours removed by this method.

RESECTION OF TRACHEA

This is a rare operation, the only indications being malignant tumours limited to the tracheal wall, and stenosis, e.g. after some cases of cut throat.§

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* *Proc. Roy. Soc. Med.*, Mar. 1925, xviii (*Sect. Laryngol.*) 25.—See also *Proc. Laryng. Soc. of London*, 1895, ii, 82, 83.

† *Trans. Amer. Laryngol. Assoc.*, 1906, xxviii, 264.

‡ Bergmann's "System of Practical Surgery," xi, 249.

§ Grey Turner, *Brit. Med. Journ.*, June 5, 1909, i, 1355.

The operation is begun as a tracheotomy. The trachea is divided transversely above and below the growth, and an endotracheal catheter with return airway immediately passed down to the bifurcation, tampons being inserted round the tubes to prevent the ingress of blood.

The operator will try carefully to avoid injury to the cervical vessels and to the recurrent laryngeal nerves during the removal of the affected portion of the trachea. The growth may have transgressed the tracheal wall and be adherent to those structures, and catastrophic bleeding may occur during this stage.

If less than 4 cm. of the trachea has been removed, it is possible to bring the cut ends of the trachea together with numerous catgut sutures,* care being necessary to prevent extension of the head for some days afterwards. Free drainage is required to guard against the escape of septic matter into the tissue planes of the neck. In certain rare cases it may suffice to remove a lateral portion of the trachea—a window. The defect can be repaired by muscle and fascia, and in one case operated upon by me the result was very satisfactory. The method is based on the experience of gunshot wounds of the windpipe.

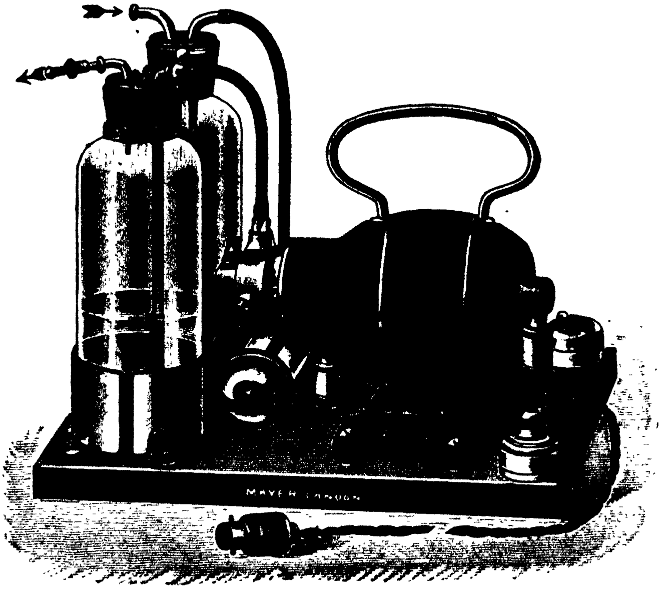

Fig. 689.—Motor used for dual purpose of sucking blood from field of operation and insufflating the anæsthetic.

Results.—Von Bruns had favourable results in seven cases ; the operation in a case of carcinoma involved removal of the posterior wall with six rings of the trachea.

Harmer obtained a satisfactory result in a case of thyroid malignancy with a small mass of growth in the trachea. The case had been first seen by a medical colleague for hæmoptysis. Local anæsthesia was employed, and severe hæmorrhage was overcome with the help of a motor suction apparatus. (Fig. 689.) The cut ends of the trachea were brought together, and the patient lived in good health for about a year.

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* Brewer, " Keen's Surgery," 1908, p. 510.

EXTERNAL OPERATIONS ON THE LARYNX

INFRATHYROID LARYNGOTOMY

Indications.—This operation is suitable (1) *in emergencies*, by reason of the speed with which it is performed, and (2) *as a preliminary* to set operations, because of the negligible amount of damage it leaves behind. It is employed in cases of sudden laryngeal obstruction by food or inhaled foreign bodies, or by œdema of the larynx due to trauma or sepsis ; it may in rare cases be necessary, to prevent cardiac failure, in crises of obstruction accompanying spasm of the glottis or bilateral abductor paralysis.

Problems of anæsthesia in large operations upon the tongue, floor of the mouth, and jaws, where bleeding is usually severe, are solved by giving intratracheal anæsthesia. Patency of the airways is thus ensured, and the anæsthetist is removed from the field of operation. A large tethered marine sponge is passed into the pharynx to prevent anything reaching the larynx from above.

The operation is only suitable for adults, as the crico-thyroid space in children will not take a tube adequate for respiration. Nor should the tube be left in for more than forty-eight hours for, though it lies in the subglottic space and the vocal cords are free from risk of injury if it is introduced carefully, yet inflammation is likely, and there is risk of ulceration with its attendant troubles if retention is prolonged.

Instruments.—Sharp-pointed knife, sharp-pointed dilator, laryngotomy-tube and tapes with pointed introducer.

Operation.—The crico-thyroid space having been identified by palpation, a small fold of skin over it is pinched up by the assistant between the forefinger and thumb of each hand. The fold is transfixed transversely with the knife, and the blade brought out through the skin. By this method there is less likelihood of injuring the veins. A sharp-pointed dilator is then forced deeply through the crico-thyroid membrane and opened widely. (Fig. 690.) It is withdrawn, and at once replaced by the tube on its introducer. The introducer is taken out, and the operation completed by tying the tapes round the neck.

No bleeding is experienced by this method, since the only vessel met with, the small crico-thyroid artery, is pushed aside by the dilators. A burst of air follows the insertion of the dilators, which should have been pushed far enough in to penetrate the mucous membrane. A period of apnœa often follows, and can be disregarded.

Complications.—If performed as described, this operation is rarely complicated. *Hæmorrhage* is uncommon, but may originate from a vein, superficial or deep, or from the crico-thyroid artery. This artery is usually small, but Durham stated that serious or even fatal hæmorrhage has occurred from it. If necessary, the wound must be freely opened, the muscles drawn apart, and the bleeding vessels secured.

Emphysema may occur if the wound is sutured or a dressing tightly applied. *Ulceration*, and more remotely *stenosis*, should not occur if the tube is not retained for more than two days.

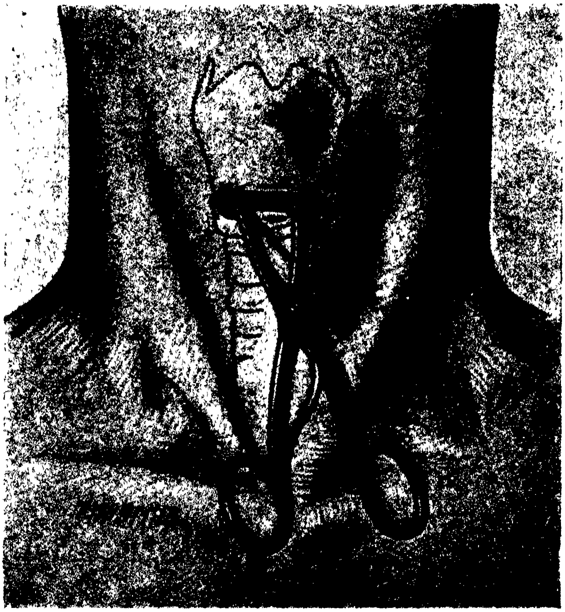

Fig. 690.—Laryngotomy : dilators tearing the crico-thyroid membrane.

CARCINOMA OF LARYNX

The remaining operative intrusions upon the larynx are chiefly used in the treatment of malignant disease which, in an overwhelming majority of cases, takes the form of epithelioma.

Classification.—(*a*) **Clinical.**—Krishaber in 1879 classified laryngeal carcinomata into :

(i) *Intrinsic*, arising from within the laryngeal box, i.e. vocal cords (80 per cent.) ; ventricles and ventricular bands (10 per cent.) ; and the region of the anterior commissure (10 per cent.)* These growths tend to remain unilateral.

(ii) *Extrinsic*, arising from the epiglottis, arytenoids, ary-epiglottic folds, pyriform fossæ, and pharyngeal aspect of the cricoid (including intrinsic growths which have transgressed their boundaries).

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* Proportions are taken from Ombrédanne, "Traitement du Cancer Endolaryngé," 1930.

(*b*) **Histological.**—Broders has further classified these growths histologically into four groups. In Group I there is well-marked differentiation of the cells, which closely resemble normal epithelium, and a tendency to form keratin or cell-nests. Invasion and metastasis are slow, and conservative surgery gives very good results. Fortunately, the majority of intrinsic growths approximate to this type. In Group IV, at the other end of the scale, the cells are anaplastic and show no tendency to form keratin or cell-nests; they invade the stroma diffusely, show active mitosis, and tend to recur early. This type of growth happens to respond readily to irradiation.

Biopsy. — Until recently, many surgeons have advised against biopsy in the belief that it might cause dissemination, but Thomson and Negus* urge biopsy. At St. Bartholomew's Hospital, where it has for some 20 years been the custom to perform biopsy on all laryngeal growths, there has been no evidence suggesting a resultant scattering of cancer-cells. In the majority of our cases the biopsy was preceded and followed by a dose of X-rays by way of precaution, but of late years this has been omitted without ill results. Biopsy, then, is advisable; and it is to be hoped that the histological guidance so obtained will lead to a satisfactory selection of cases for the various forms of treatment.

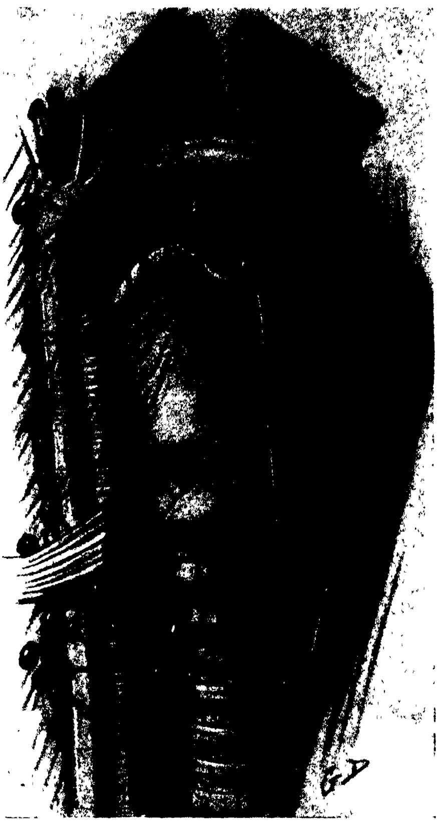

Fig. 691.—**Laryngeal lymphatics.**

The drainage from the vocal cords leaves the larynx through the crico-thyroid space.

(*After Poirier and Cunéo.*)

Intrinsic lymphatics.—Apart from histological considerations, the difference between metastasis from intrinsic and extrinsic growths is largely explained by the differences in the direction and extent of the lymphatic drainage. The cords are not well served in the matter of drainage; the lymphatic vessels are scanty, and the spread through them is very slow, being limited for considerable periods to one or two glands over the crico-thyroid membrane, where they can be felt as small shot-like bodies. (Fig. 691).

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* "Diseases of the Nose and Throat," Cassell, 1937.

Very different is the drainage from the supraglottic region. The lymphatic vessels here are plentiful, and the spread is immediate, to the deep cervical chain, especially the digastric gland and the gland on the carotid bifurcation.

Treatment for intrinsic growths.—The choice of treatment lies between surgery with or without diathermy, on the one hand ; and the interstitial application of radium on the other. The majority of writers are strongly in favour of the former.[*]

Surgical.—The choice of operation depends on the stage which the growth has reached, and as a rule three phases are recognized. The first phase of an intrinsic growth is easily definable : the growth is limited roughly to the middle third of one cord and the cord is freely mobile. In these cases it is possible to obtain a 5-year cure in over 80 per cent. of cases by laryngo-fissure.[†] The operative mortality is almost negligible. Chevalier Jackson[‡] performed 120 consecutive laryngo-fissures with no postoperative deaths.

Phonation is usually surprisingly good : the scar tissue on the affected side heaps itself up so as to look remarkably like a vocal cord by peroral laryngoscopy, and the intact cord plays against this ridge so as to produce a rather thin but effective voice, which can be greatly developed by education.

1. LARYNGO-FISSURE

Indications.[§]—

1. Neoplasms of the larynx.
2. Impacted foreign bodies in the larynx.
3. Injuries of the larynx.
4. Laryngocele.
5. Stenosis of the larynx and certain operations for relief of abductor palsy.
6. Acute laryngeal perichondritis.
7. Laryngeal tubercle.
8. Scleroma of larynx.

Preliminary considerations.—The complications to be feared are firstly, infections of the lower respiratory tract, and secondly, descending infection behind the pretracheal fascia, with its risk of mediastinitis.

It is wise to precede the main part of the operation by tracheotomy, and to carry on the anæsthesia through the tube, great care being taken to prevent blood from the operation area entering the lung. This end is furthered by having the trachea tilted, either by extending the head downwards over a sand-bag under the neck, or by tilting the table.

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[*] E. N. Broyles, *Arch. Otolaryng.*, 1936, xxiv, 475.

[†] G. E, New and F. A. Figi, *Surg. Gyn. Obstet.*, 1936, lxii, 420.

[‡] *South Surg.*, 1932, i, 223, and *Surg. Gyn. Obstet.*, 1934, lviii, 431.

[§] St. Clair Thomson and Negus, " Diseases of the Nose and Throat," Cassell, 1937.

Tracheotomy ensures the maintenance of a clear airway, with elimination of straining, congestion and bleeding. There is a growing tendency among French surgeons to dispense with tracheotomy in this operation. In England it is customary to employ general anæsthesia, and in skilled hands excellent results are obtained. Though pain can be abolished by local anæsthesia, other sensations are experienced and these to some patients are more distressing than pain. Considerable shock sometimes follows a painless operation, nor can we guarantee freedom from pulmonary complications and the like by the avoidance of general anæsthesia.

Instruments.—Tracheotomy set, thyroid-cartilage shears, two large retractors, long curved scissors, periosteal elevator, aneurysm-needle.

Operation for intrinsic growth. First stage : tracheotomy.—A median vertical incision is made from the hyoid bone to the suprasternal notch, and its lower half is deepened to expose the thyroid isthmus and the trachea. A median tracheotomy is performed (*see* p. 1445), and the largest Jackson tube is inserted and connected up to an apparatus for the insufflation of the anæsthetic through a tube long enough to keep the anæsthetist outside the field of operation.

Second stage : exposure of the larynx.—The upper portion of the incision is now deepened so as freely to expose the thyroid and cricoid cartilages, and bleeding-points are secured. Diggle* at this stage makes a small incision extending laterally from the upper end of the wound on the side corresponding to the growth, and through it he ligatures the superior laryngeal artery before it passes under the thyrohyoid muscle. This prevents even the small amount of bleeding that is usually encountered in the later stages.

Lying on the crico-thyroid membrane will usually be found a small lymphatic gland—sometimes two—which it is important to remove as it is on the path of lymphatic drainage through the crico-thyroid membrane from the subglottic portion of the larynx. (Fig. 691.)

Third stage.—The perichondrium on the thyroid cartilage is now incised. The division may be mesial, or a few millimetres from the middle line on the side opposite to the growth, so as to avoid cutting into a growth which has invaded the opposite cord under cover of the anterior commissure. The thyroid cartilage is split from below upwards in the line of this incision, care being taken to avoid unnecessary damage to the anterior commissure with a view to conserving vocalization.

The divided alæ are held widely aside and the mucosa is sprayed with a solution of 10 per cent. cocaine and adrenalin, and the surface of the growth is painted with spirit. A long ribbon of gauze is packed down on the sponge inserted in Stage 1. The growth is always infected and is also to be regarded as covered with cancer cells likely to be disseminated in the wound ; technique must be arranged in appreciation of these facts.

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* *Pract.*, 1923, cxi, 356.

The alar cartilage of the affected side is freed from the perichondrium both within and without, and is removed* with the exception of a small strip posteriorly. This step facilitates examination of the growth and avoids the delay in healing otherwise caused by the granulating surface of the cartilage.

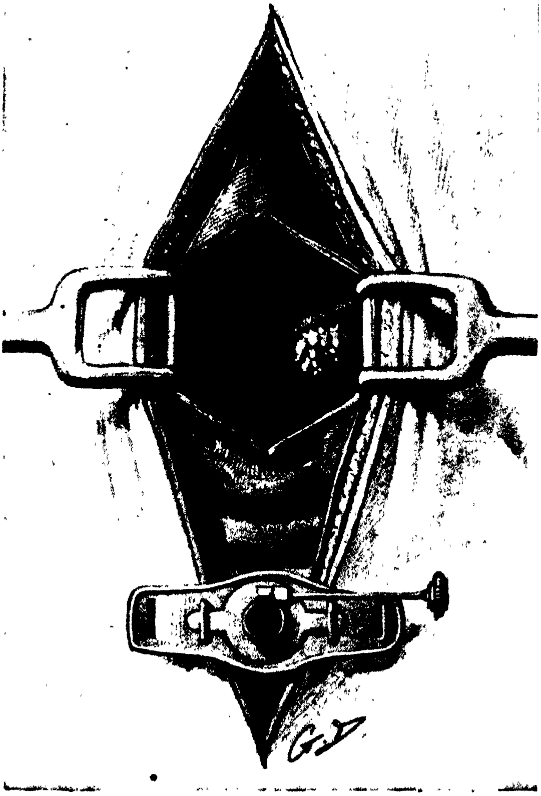

Fig. 692.—Laryngo-fissure.

The lungs are shut off by the insertion into the trachea, above the tube, of a tethered wad of gauze or sponge of a size and shape accurately to fill the trachea.

Fourth stage : removal of the growth.—The perichondrium and soft parts on the side of the growth are separated from the inner surface of the cartilage by some form of elevator, as far backwards, upwards and downwards as the instrument will pass ; and with thin, long scissors an incision through the muco-perichondrium is carried round the tumour, a margin of over ¼ in. of healthy tissue being included. If the growth involves the anterior end of the cord, as much of this as is necessary must be sacrificed, while posteriorly it may be necessary to remove part or all of the arytenoid cartilage. If the vocal process only has to be removed, no disturbance results; but if the arytenoid is sacrificed, the surgeon must be prepared for dysphagia and the inhalation of fluids, with its attendant risk of pneumonia, for some days afterwards.

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* St. Clair Thomson and Negus, "Diseases of the Nose and Throat," Cassell, 1937.

Fifth stage : closing the larynx.—The packing having been removed, the alæ are allowed to fall together, accurate replacement being facilitated by a notch made earlier. If necessary, they are held together by catgut sutures through the perichondrium covering them, and the wound is sutured *only as far down as the tracheotomy-tube.* It is usual to leave the tracheotomy-tube in position for twenty-four hours with a view to avoiding the risks due to reactionary hæmorrhage.

After-treatment.—Patients should be nursed in a sitting position, which facilitates breathing and the expectoration of mucus and blood. It is well to insert a stomach-tube *via* the nose for feeding purposes until deglutition is satisfactory.

After excision of a growth, silence is imposed for ten days.

Complications.—*Hæmorrhage,* reactionary or secondary, may occur, and septic pneumonia from reactionary hæmorrhage has been the greatest cause of fatalities.

Reactionary hæmorrhage can be largely obviated by preliminary ligature of the superior laryngeal artery, and by retention of the tracheotomy-tube for twenty-four hours. Secondary hæmorrhage is rare, and is usually fatal.

Emphysema should not occur if that part of the wound below the tracheotomy opening is not sutured.

Mediastinitis is a rare and fatal complication. It is unlikely in patients who have been freed beforehand from infective processes in the teeth and the upper air-passages. It is due to the downward passage of infection from the operation area behind the pre-tracheal fascia, and can be avoided to a large extent by drainage of the lower portion of the wound.

In **laryngo-fissure for stenosis** the cavity of the larynx is restored by the submucous removal of all fibrous tissue, care being taken to preserve any attached mucosa which is viable. Any raw areas remaining may be epithelialized either by skin-grafting or by some modification of the *pansement en cigare,* followed by intubation, as recommended by Moure.* He plugs the cavity with a cigar-shaped wad of tightly rolled gauze for six weeks, changing it occasionally. A vulcanite tube is worn for some months until epithelialization is complete. The laryngeal cavity is then restored by plastic means.

PARTIAL LARYNGECTOMY

The first phase of an intrinsic growth is definable, and indications for treatment are clear cut, but when this stage has been passed, we enter on debatable ground. Definition is difficult, as is also the presentation and the interpretation of results. Hautant[*] perceived a phase which may be more or less clearly defined and for which some form of partial laryngectomy is indicated, and has devised an operation for dealing with it; this may be regarded as typical of all partial laryngectomies. Hemi-laryngectomy, designed for the excision of half an organ rather than the removal of a disease, has been discarded. It destroyed the laryngeal functions, including the prevention of inhalation of harmful substances. Hautant's operation, while meeting the indications of satisfactory excision of the growth, recognizes that this is not incompatible with the preservation of the major part of the larynx with its functions.

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* *Path. de Guerre*, 1917.

Operation. **First stage.**—Under local anæsthesia, the larynx and trachea are exposed by an incision in the middle line, from the hyoid bone down to the suprasternal notch.

Second stage.—Clearly a midline incision through the thyroid cartilage begs the question of unilaterality; and, as it is very difficult to determine by laryngoscopy whether the growth has invaded the opposite side of the larynx by way of the anterior commissure, an incision through the thyroid cartilage is made, about 5 mm. lateral to the incisura, on the side remote from the growth. The membranous larynx is respected throughout this stage, by careful separation of the muco-perichondrium from the cartilage. A second incision through the thyroid cartilage, on the side occupied by the growth, is made as far lateral as is consistent with the preservation of some attachment for the inferior constrictor of the pharynx. The cricoid cartilage is now cut through in the middle line, after a preliminary separation of the underlying muco-perichondrium, followed by a second incision on the side of the growth, as far lateral as the point where the cricoid suddenly begins to broaden. The pieces of cartilage thus outlined are removed.

Third stage.—Blunt dissection is made backwards to separate the membranous larynx from the cricoid cartilage. When the dissection reaches the arytenoids, a crucial point in the operation occurs, the arytenoid on the affected side being cut through so as to divide the processus vocalis from the main body of the cartilage. This manœuvre ensures preservation of the "inter-arytenoid curtain," upon which the hope of future deglutition obviously depends.

Fourth stage.—The lumen of the larynx, hitherto preserved to limit the risks of sepsis, is now entered; and the growth, accompanied by as much tissue as is necessary to guarantee a healthy margin, is removed. The portion ablated usually includes a small piece of the opposite cord, the vocal process of the arytenoid, the ventricle of the larynx, and the ventricular band.

Fifth stage.—The wound is closed; and the patient is able immediately to take fluids. Although Hautant described tracheotomy as part of the operation, it should not be necessary with intratracheal anæsthesia.

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[*] Ombrédanne, "Traitement du Cancer Endolaryngé," 1930.

Results.—Obviously the post-operative mortality of partial laryngectomy will depend chiefly on the selection of cases. Hautant (*loc. cit.*) had a postoperative mortality of 3 per cent. and over 60 per cent. of 2-year cures, the recurrences being only among those in which the mobility of the cord was impaired.

LARYNGECTOMY

Indications.—The criteria separating cases suitable for partial laryngectomy from those in which the whole organ must be sacrificed are not, in their very nature, clearly cut ; but commencing *thickening of the ary-epiglottic fold* is critical. It foreshadows invasion of the pyriform fossa of the pharynx with the free lymphatic spread which is the heritage of intrinsic growths, and calls for laryngectomy. Once a growth has bulged into the sinus pyriformis, it is frankly extrinsic, and is usually inoperable. More judgment is demanded in assessing the importance of spread in other directions.

A *subglottic extension*, if very small, may still be removed by splitting the larynx ; invasion of the *perichondrium*, or of the *crico-arytenoid joint*, which leads to fixation of the cord, is a clear indication for laryngectomy, but partial laryngectomy is often successful if mobility is only slightly impaired. A *forward*-spreading growth is operable and can be removed by partial or complete laryngectomy so long as it has not perforated the cartilage under the anterior commissure. When it has done so it tends to spread rapidly in the skin *en cuirasse*, which not only negatives partial laryngectomy, but does away with any hope of a healthy plastic closure.

Operation (one-stage).*—**Exposure and freeing of the anterior and lateral aspects of larynx.**—(*a*) *Incision.*—A bluntly triangular flap is desirable, to minimise the chances of the pharynx breaking down afterwards. (Fig. 693.) But if scar-tissue, e.g. from previous irradiation, prejudices the viability of a flap, a I-shaped incision is satisfactory.

(*b*) The larynx is now " skeletonized " by the removal of the infrahyoid muscles and the sterno-thyroid as far down as the lower border of the cricoid, and the upper three rings of the trachea are exposed by retracting the thyroid gland downwards.

(*c*) The trachea is divided obliquely so that its upper end looks forwards, and a well-fitting rubber tube is introduced into it for the anæsthetic (MacKenty).

(*d*) The superior laryngeal vessels having been clamped and tied, the pharyngeal muscles are detached, the larynx being tilted from side to side. At this stage the carotid sheath is examined and any involved lymphatic glands (unlikely, in operable cases) are dissected off the jugular vein.

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* Modified after Colledge.

Separation of larynx from pharynx and tongue.—The thyroid cartilage is pulled forwards with a hook which stretches the thyro-hyoid membrane so that it can be easily separated off the larynx, and the pharynx is plugged from below with a sponge. It is now possible to seize the epiglottis and pull the larynx forwards so as to see into the hypo-pharynx ; the laryngo-pharynx is then severed just below the arytenoids by a transverse incision down to the cricoid, and the mucosa is peeled downwards off the cartilage. Care must be taken to avoid perforation of the mucosa, which is particularly likely during the separation of the larynx from the mucosa lining the pyriform fossæ. A rubber feeding-tube is introduced into the œsophagus through the mouth or nose, and the raw edges of the pharynx are inverted and sewn together over it by submucous catgut sutures. Additional sutures uniting the pharynx with the thyro-hyoid membrane help to prevent post-operative fistulæ, and the pharynx is further buttressed by sewing the constrictors together over it.

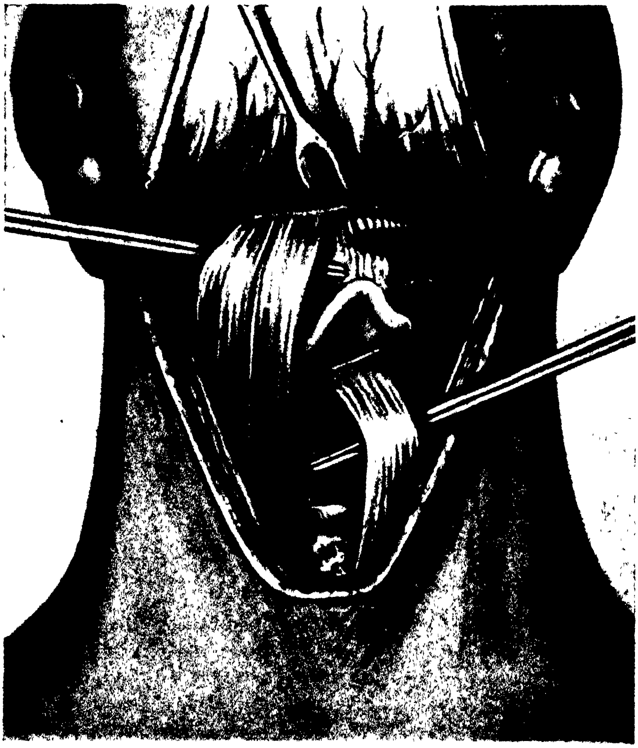

Fig. 693.—Laryngectomy. The skin-flap has been retracted. The muscles are detached from the hyoid bone and thyroid cartilage.
(From Thomson and Negus, " *Diseases of the Nose and Throat.*")

Removal of the larynx and drainage.—Separation of the larynx is completed by division of the posterior wall of the trachea, and its upper posterior extremity is accurately attached to the lower edge of the skin-flap, the anterior edge of the trachea being sewn to the lower margin of the wound. Drainage is secured by tubes (Fig. 694) which are arranged to project so that the discharges may be directed away from the trachea.

The **results** of laryngectomy for intrinsic cancer vary between 56 per cent. of 5-year cures reported by Waugh* to 35 per cent. of 3-year cures reported by Hajek.† The mortality (chiefly due to inhalation pneumonia) was originally prohibitive. MacKenty, however, reduced it to 8 per cent. by adopting Solis-Cohen's method of isolating the trachea and bringing its orifice out on to the neck. More recently New‡ published 65 cases with only one death.

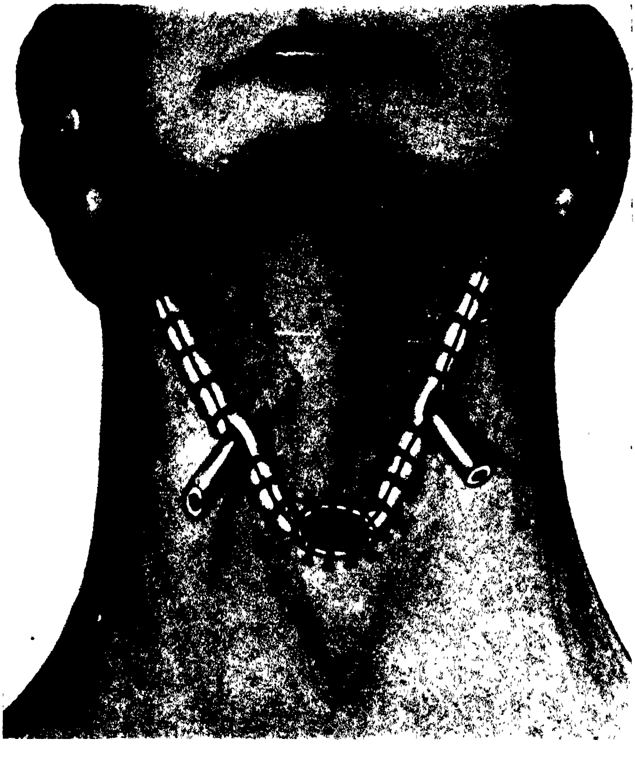

Fig. 694.—Drainage after closure of the flap.

(From Thompson and Negus, *Diseases of the Nose and Throat*).

DIATHERMY

Many surgeons (New, Broyles (*loc. cit.*)) combine thyrotomy with diathermy in early cases ; while Lynch§ combined diathermy with excision *via* the mouth.

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* *Surg. Gyn. Obstet.*, 1934, lviii, 851.

† *Mschr. f. Ohrenh.*, 1935, lxix, 385.

‡ *Trans. Amer. Med. Ass.*, (Laryngol. Sect.), May, 1936, lxxxvii, 262.

§ *Trans. Amer. Laryngol. Assoc.*, 1920, xlii, 119.

IRRADIATION

Irradiation in various forms has certain advantages, particularly in rapid growths showing anaplasia and mitosis. It may be used in conjunction with surgery ; Broyles (*loc. cit.*) quotes 26 cases at John's Hopkins Hospital, and says that the only cases which were " really cured " were those in which complete removal had been followed by irradiation. He does not say by what means. The means would, however, appear to be an important factor, for while Harmer and Finzi* found that 6 out of 8 cases of intrinsic carcinoma were well from one to three years after the implantation of radium needles, Levitt (1927), in a personal communication, reports only two 3-year survivals out of 7 cases of intrinsic cancer treated by X-rays from 1924 to 1932 ; while Stewart Harrison† reports 6 cases out of 15 well for 3 years after Rœntgen treatment. Lambert and Watson‡ report promising results in 11 cases of unilateral growths treated by " contact " X-rays applied immediately after removal of thyroid ala.

Technique.—Where it is possible to expose the whole growth to radium, platinum-iridium needles containing radium bromide or radium emanation are implanted. The containers usually have a " unit linear intensity " of ½ mg. of radium element per cm. of active length, to ensure a lethal dose to a cylinder of tissue about 2 cm. in diameter after about seven days' exposure.

Filtration is of extreme importance ; damage to normal tissue cannot be avoided unless the wall of the container is 0.6 mm. thick or more. Whereas needles can in other parts of the body be inserted through the skin, in laryngeal cases it is necessary surgically to expose the area involved, care being taken to keep the wound aseptic by keeping out of the lumen. It was formerly considered that removal of more than one-third of the circumference of the cartilage of the larynx or trachea would inevitably cause collapse and consequent obliteration of the airway. But it has been found possible to remove the whole of the narrow part of the cricoid, as well as practically the whole of one ala of the thyroid and a considerable portion of the other, without noticeably prejudicing the airway.

It is, therefore, possible adequately to expose all the antero-lateral parts of the larynx to irradiation ; and an operation for the implantation of radium-needles for a carcinoma involving the whole of the vocal cord has been successfully carried out (Fig. 695) with disappearance of the growth for 2½ years. The cartilaginous removals here shown are an extension of those employed by Hautant in his " Laryngectomies Economiques."

After the removal of the cartilage the growth may often be seen shining through the underlying perichondrium, which is carefully respected. The needles are laid upon it, their inactive portions often being tucked under a neighbouring edge of cartilage, and the wound closed. Their removal, a week later, does not require an anæsthetic.

Shrinkage of the growth is usually evident even before the needles are removed, and intrinsic carcinomata disappear within three weeks as a rule.

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* *Brit. Med. Journ.*, 1928 ii, 886. † *Journ. Laryngol. Otol.*, 1932, xlvii, 725. ‡ *Ibid.*, No. 4, 1942, lvii, 222.

Treatment should include diathermic removal of the successfully irradiated area when feasible.

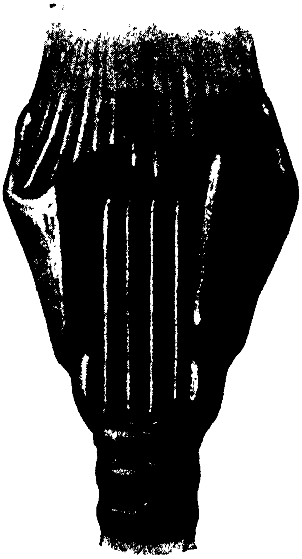

Fig. 695.—Implantation of radium needles for intrinsic carcinoma.

TREATMENT OF EXTRINSIC GROWTHS

The treatment of extrinsic growths is unsatisfactory. Few surgeons now advocate excision, and I have had uniformly bad results from the implantation of radium-needles. Souttar* stresses the importance of accuracy and uniformity of dosage, and has elaborated a method of implanting two opposing plaques of dental wax in which radium needles are imbedded ; this gives a uniform dose of radium to the whole of the desired area. Victor Lambert† records good results from the use of contact irradiation in laryngeal carcinoma. Details will be found in his paper.

The late results of treatment by X-rays is very disappointing. Levitt (1937) reports five 3-year survivals out of 94 cases treated between 1924 and 1932, and two 5-year survivals out of 67 cases. But the immediate results are amazingly good ; in the majority of cases there is disappearance of the growth for over 12 months.

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* *Brit. Med. Journ.*, May 1, 1937, i, 909.

† *Journ. Laryngol. Otol.*, April, 1942, lvii, 222.

CHAPTER XXXII

INVESTIGATION OF THE UPPER AIR AND FOOD PASSAGES

By V. E. NEGUS and G. GREY TURNER

DIRECT LARYNGOSCOPY, PHARYNGOSCOPY AND BRONCHOSCOPY

Surgical anatomy.—In an endoscopic examination the following are the chief points of anatomical interest. The *epiglottis* lies at the base of the tongue and is a necessary landmark in direct inspections. Its lateral margins are continuous with the *ary-epiglottic folds* which meet behind the larynx and form the boundaries of the laryngeal aperture. Approximation of the folds against one another, associated with their apposition to the epiglottis, closes the larynx during swallowing. The internal aspect of each ary-epiglottic fold is continuous with the *ventricular band* of which the free lower margin forms the upper boundary of the *ventricle.* Below the latter lies the *vocal cord,* a broad white fold stretching from the thyroid cartilage anteriorly to the arytenoid cartilage posteriorly.

The trachea is 11 cm. (4½ in.) long ; it bifurcates at the level of the second costal cartilage into the right and left main bronchi. *The right main bronchus* is shorter, wider and more nearly continuous with the trachea than that of the other side ; it gives off the eparterial bronchus and the middle-lobe bronchus and continues as the bronchus to the lower lobe. *The left main bronchus* is longer than its fellow and is given off at a greater angle from the trachea ; it divides into two branches, the upper lobe bronchus and the lower lobe bronchus.

The septum between the right and left main bronchi, the carina, is situated to the left of the middle line. When viewed through the bronchoscope it appears as a sharp ridge, on either side of which are seen the openings of the main bronchi.

DIRECT LARYNGOSCOPY AND PHARYNGOSCOPY

These two examinations may be described together, as they entail the same technique and the use of the same instruments. The larynx and pharynx should always be examined indirectly with a mirror before making the direct examination.

Indications for use of laryngoscope.—

(1) Removal of a foreign body from the base of the tongue or from the larynx.
(2) Examination of a neoplasm of lower pharynx or larynx, and for biopsy.
(3) Examination and treatment of laryngeal stenosis.
(4) Treatment of laryngeal diphtheria.

Technique.—The direct examination is carried out by means of a laryngoscope or speculum, either of the Chevalier Jackson type in which the light is distal, or of that designed by Brünings and modified by Kahler and Haslinger, in which the electroscope is in the handle. The former type is preferred, as the passage of instruments down the tube does not cut off the illumination. Laryngoscopes of the type devised by Negus are efficient ; the light is derived from twin lens-fronted lamps placed obliquely on either side of the laryngoscope at its proximal end.

Position of patient.—The laryngoscope is passed with the patient lying on an operating table, with the head supported by the hand of an assistant, or preferably by a mechanical head rest.

Anæsthetic.—If the pharynx and larynx are painted with a 10 per cent. solution of cocaine to which an equal part of adrenalin has been added, this will suffice in most cases ; in some cases a general anæsthetic is necessary (*see* p. 1470). In the former case a preliminary injection of omnopon gr. $\frac{1}{3}$ and scopolamine gr. 1/150 should be given one hour and a half before the examination ; the omnopon may be repeated half an hour before operation, unless the patient is very drowsy.

Passing the laryngoscope.—The patient is placed in the recumbent position with the head so raised that the occiput is 10 cm. (4 in.) above the level of the table ; the head is well extended. The instrument is passed over the dorsum of the tongue until the epiglottis is identified ; the hypopharynx and pyriform fossæ can then be inspected. The tip of the tube is next passed behind the epiglottis, when the interior of the larynx will come into view. Care should be taken, in introducing the tube, that the patient's upper lip is not caught between it and the upper teeth. In some cases in which the upper incisor teeth are very prominent the tube may with advantage be introduced through the side of the mouth. If there is difficulty in inspecting the anterior extremity of the vocal cord, a narrower tube, the anterior commissure laryngoscope, may be used. Its beak can be inserted between the ventricular bands for close inspection of the vocal cords.

BRONCHOSCOPY

Indications.—

(1) Removal of foreign bodies lodged in the air passages.
(2) Dyspnœa in which some obstruction of the air passages is suspected, either from narrowing of the passage itself or from pressure from outside by mediastinal new growths.
(3) Examination and treatment of cases of bronchial abscess, lung abscess and bronchiectasis.
(4) Diagnosis and treatment of new growths of the trachea or bronchi.
(5) In new growths of the œsophagus, to detect commencing invasion of the bronchial tree.

Instruments.—The following instruments are essential; others may be needed for special cases: bronchoscopes of four sizes for adults, adolescents, children and infants; long swab-carriers; a suction apparatus with bronchial suction tubes, and bronchoscopic forceps of various types for removal of foreign bodies and for biopsy.

Position of patient.—The position of the patient is much the same as the recumbent posture in œsophagoscopy (*see* p. 1476 and Fig. 696). When the tube is just above the bifurcation of the trachea the surgeon may, by bending the head towards one or other shoulder, bring the long axis of the tube into that of either bronchus and so facilitate the passage of the beak of the tube into the corresponding bronchus.

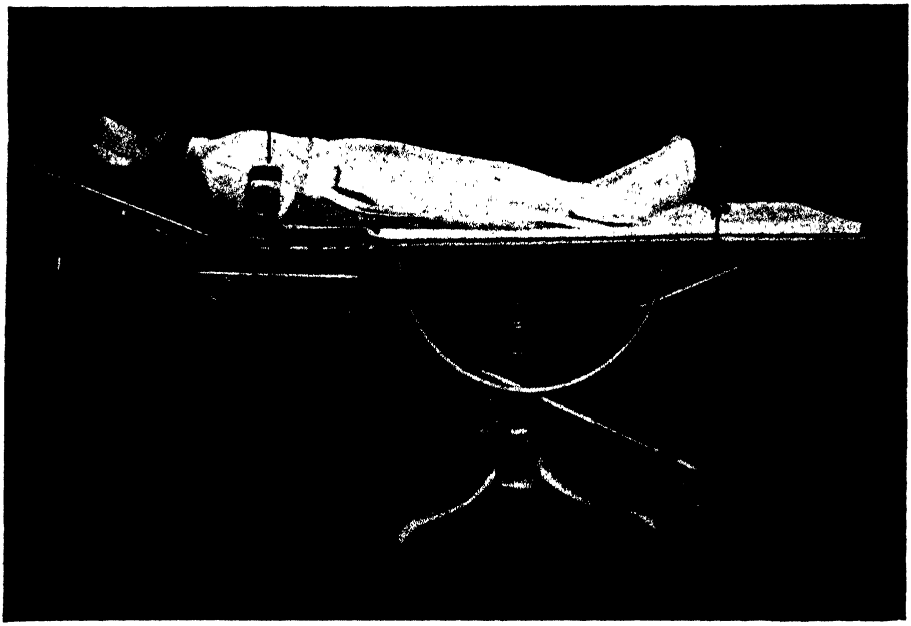


Fig. 696.—Position for bronchoscopy.

Anæsthesia.—Bronchoscopy can be carried out under local anæsthesia with little discomfort to the patient if omnopon and scopolamine are given beforehand and if the pharynx and larynx are well anæsthetized with cocaine. In children, rectal paraldehyde is of value, followed, if necessary, by inhalation anæsthesia. Adults can, if essential, be given avertin, followed by some general inhalation anæsthetic; or a combination of local anæsthesia and pentothal may be used.

Passing the bronchoscope.—The operator stands at the head of the table, and the instrument is passed under direct vision through a laryngoscope. The laryngoscope is introduced in the midline over the tongue until the epiglottis comes into view. It is then directed behind the epiglottis, and the bronchoscope is passed through it, with the beak of the tube parallel with the vocal cords ; the bronchoscope is passed gently between the cords into the trachea. The laryngoscope is then removed, after withdrawing its slide. On reaching the bifurcation, the carina and both bronchial orifices are carefully inspected before advancing the tube into either bronchus. If the left bronchus is to be entered, the patient's head must be inclined towards the right shoulder ; if the right, towards the left shoulder. Examination of the bronchi must be systematic and careful, and the orifices of the secondary bronchi must also be inspected. The secretion, which in some cases is profuse, should be removed by suction or by sponging.

Foreign bodies.—Smooth foreign bodies should be grasped with appropriate forceps and withdrawn slowly, together with the tube. Sharp-pointed objects, such as pins and staples, should be dealt with very carefully and no force used in their extraction, otherwise irreparable damage may be done if the point is embedded in the wall of the bronchus. The pointed end should be first disimpacted by forceps, and manipulated into the mouth of the tube ; held in this position, the foreign body and the tube may safely be withdrawn together. Friable vegetable foreign bodies may be removed with delicate grasping forceps ; small detached fragments are dealt with by aspiration with an electric suction pump.

Neoplasms.—A small snip for microscopical examination may be removed with punch forceps. Occasionally this is followed by smart hæmorrhage, which should be arrested by the pressure of a swab saturated, if necessary, with 1 in 1,000 adrenalin or with 10 per cent. protargol.

EXAMINATION OF THE ŒSOPHAGUS

Surgical Anatomy

The œsophagus begins at the level of the sixth cervical vertebra, behind the cricoid cartilage. The level of demarcation from the hypopharynx is at the crico-pharyngeal fold. This fold is produced by the contraction of the crico-pharyngeal sphincter, constituted by the lowest fibres of the inferior constrictor muscle. In the average adult the œsophagus begins 14 to 16 cm. (5–6 ins.) from the upper teeth, and passes through the thorax to join the stomach 3 to 5 cm. (1½ to 2 ins.) below the diaphragm. Its total length is usually about 23 to 25 cm. (9 to 10 ins.), but it may be as much as 28 cm. It is convenient to speak of the normal points of narrowing in distances from the upper teeth. These points are found at the crico-pharyngeal fold, 14 to 16 cm. (5–6 ins.), at the level of the aortic arch, 23 cm. (9 ins.), at the point where the left bronchus crosses, 27 cm. (11 ins.) and at the diaphragmatic hiatus opposite the 10th dorsal vertebra, 36 to 40 cm. (15–16 ins.). The upper end of the œsophagus is in the midline but its direction is slightly to the left before it passes between the crura of the diaphragm.

It may be regarded as a long strap-like hollow muscle. The walls are thin, 3 to 4 mm. (3/16ths in.) and consist of an external fibrous coat, an outer longitudinal and an inner circular muscular coat, a well marked submucous layer of areolar tissue, and an internal mucous membrane of squamous-celled type. In the mucous membrane there may be areas of heterotopic gastric type. The tube lies in a bed of loose cellular tissue in which it can move freely during swallowing and body movements. In parts, this cellular tissue is dense and forms ligamentous connections with the left bronchus and the arch of the aorta, but for the most part it is a soft loose bed in which the finger can easily travel with little resistance.

The important relationships are : anteriorly, the trachea and left bronchus, which crosses it ; the pericardium and the left vagus nerve ; posteriorly, the cervical and thoracic vertebræ, thoracic duct, descending aorta and right vagus ; laterally, the pleura ; the arch of the aorta on the left, and on the right the arch of the azygos vein. The recurrent laryngeal nerves lie in the groove between the œsophagus and trachea in its upper third and may be involved in œsophageal diseases. These relationships can best be studied in transverse sections of the thorax. (Fig. 697.) The relations of the pleura are most important as they are concerned with so many of the consequences of pathological conditions and have a close bearing on the question of direct surgical interference. On the right side the pleura is in relation with practically the whole length of the œsophagus, while on the left it is only separated from it by the prominence of the aorta in its middle part. At the lowest part of the thoracic œsophagus the left pleural sac passes behind the tube, where it may sometimes meet the pleural sac of the opposite side. (Fig. 698.)

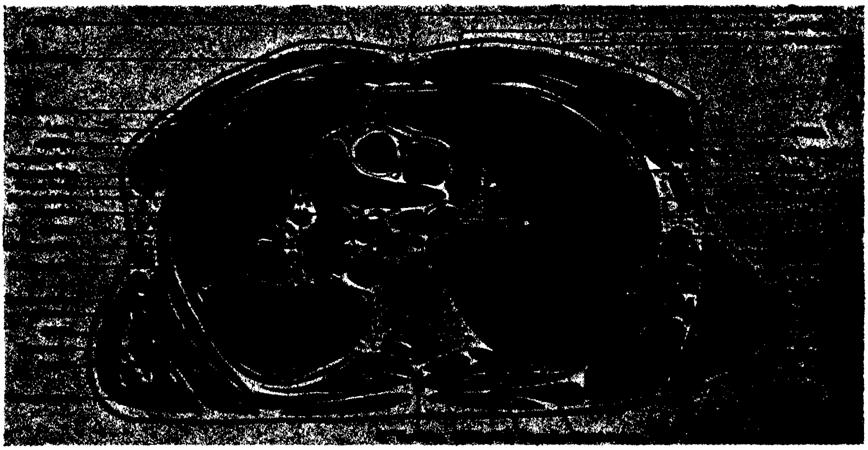


Fig. 697.—Transverse section of thorax, showing relations of œsophagus at level of 5th thoracic spine.

(Reproduced from Symington's "Atlas of Topographical Anatomy," by permission of the Anatomical Society of Great Britain and Ireland.)

The upper œsophagus is a potential tube, compressed antero-posteriorly between the trachea and the vertebral column. The crico-pharyngeal sphincter keeps the mouth of the œsophagus closed to prevent the entrance of air during respiration. The walls of the thoracic portion of the gullet are lax and are seen to move freely with the respiratory excursions when the œsophagoscope puts the sphincter out of action. The diaphragmatic orifice is closed in a rosette-like manner ; this is probably due to the fact that the walls of the abdominal œsophagus are kept in apposition by the mutual coaptation of the abdominal viscera. There may be, in addition, a feeble intrinsic sphincter at the lower end. In man the sphincter mechanism is probably assisted by the muscular portion of the diaphragm and by the slight forward obliquity of the tube as it passes to join the stomach.

During swallowing the crico-pharyngeal sphincter relaxes as the food, assisted if necessary by the propulsive wave of the pharyngeal constrictors, passes into the œsophagus. Weak peristalsis occurs in the œsophagus during normal conditions, and the passage of food may be somewhat assisted by gravity ; but the act of swallowing is a co-ordinated mechanism depending on the relaxation of the sphincters and the contraction of the propelling muscles at the correct moment. The pharyngeal muscles undoubtedly supply the most important part of the propelling force.

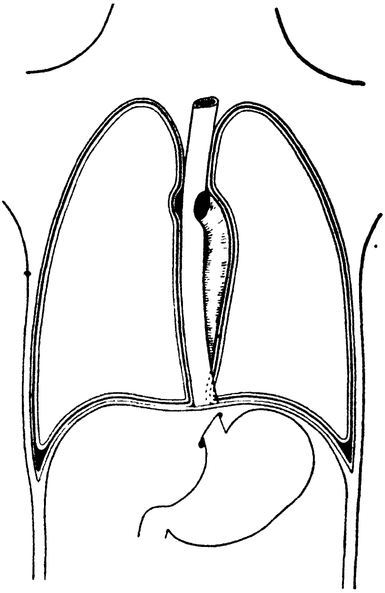


Fig. 698.—Relations of œsophagus and pleura.

(Dissection and drawing by Mr. James Whillis). Reproduced, by permission, from *The Lancet*.

INSPECTION AND PALPATION

These methods may give a little information when a pouch is present in the neck, or when secondary malignant glands are found above the clavicle, or in some cases where an œsophageal growth may be actually felt in the cervical portion. In the same way, a neoplasm of the lower end of the œsophagus may invade the abdominal part and be felt as an epigastric lump. Indirect laryngoscopy may show a collection of frothy saliva and mucus in the pyriform fossæ, or paralysis of one vocal cord, more often the left ; and occasionally the upper edge of a malignant growth arising in the cervical œsophagus can be seen behind the cricoid cartilage. In all cases of difficulty in swallowing it is essential to exclude causes in the mouth, pharynx, larynx or stomach, before proceeding to instrumental examination of the œsophagus itself. Similarly, physical examination of the lungs, heart and mediastinum may be required, because pathological conditions in these organs may sometimes cause distortions by pressure or displacement.

X-RAYS

Radiography is of great assistance in diagnosis and may be most helpful in deciding on treatment. The lumen of the gullet may be outlined by barium, swallowed as a cream or thick paste, or taken as biscuits. Actual observation of opaque material seen by the screen must always supplement the films taken. In the cervical region a carcinoma of the œsophagus may be shown in outline by a soft-tissue radiograph; here, too, perforation may be revealed by the presence of air between the posterior œsophageal wall and vertebral column. The bulk of a growth may lift the trachea forward, and this will be demonstrated by the outline and the displacement of the column of air in that tube.

Pouches are usually well shown, but views in different positions must be made. In stricture, the œsophagus above the obstruction fills with opaque material and defines the upper border, thus showing whether the lumen is regular and tapering or irregular in outline. The former is characteristic of simple and the latter of malignant disease. The stricture itself may be delineated, but the œsophagus below this level may not be well defined. If the position and outline of the lower limit of the obstruction is to be demonstrated the patient must swallow barium while reclining, and then adopt the Trendelenburg position immediately the opaque material has passed through the stricture. This causes the barium to flow back and fill the lower segment of the œsophagus, thus affording additional information. This technique is particularly useful in cases of short œsophagus with intra-thoracic stomach. The X-ray also demonstrates the degree of dilatation above an obstruction and so provides some indication of the duration of the disease; in achalasia, the œsophagus may be enormous, but in malignant disease there has seldom been time for it to become much dilated.

BOUGIES

Sounding the œsophagus has been largely discarded in recent years in favour of radiography and direct examination which, in the hands of those specially trained and experienced, give much more accurate information with less danger. But these special methods may not always be available or, in the hands of the inexperienced, may be more dangerous than bougies. The soft mercury-filled bougie associated with the name of Sir Arthur Hurst traverses the œsophagus by its own weight and can on occasion be used to determine the presence and site of an obstruction and to give some indication of its nature; it is a very safe instrument.

ŒSOPHAGOSCOPY

Œsophagoscopy is a much more accurate means of diagnosis and is often most useful in treatment ; but in the hands of the unskilled it may be dangerous, and deaths from injuries and even perforation of the œsophageal wall have occurred. Practically the only contra-indication is well-developed aneurysm of the aorta. In advanced malignant disease œsophagoscopy may serve no useful purpose and may, indeed, precipitate some such complication as hæmorrhage or perforation. On the other hand, by permitting visual dilatation, it may be the means of re-establishing the power of swallowing.

Instruments required.—1. **The operating table** must be steady ; it is much more useful if it can be raised, lowered and tilted. A mechanical head rest is a help as it dispenses with the need for a specially trained assistant and leads to accuracy in instrumentation. Negus has introduced such a rest which simplifies the technique of peroral endoscopy (Fig. 699.) It is similar to the apparatus of Haslinger, but is rather more elaborate. It can be clamped on to most operating-tables, and consists of a movable extension carrying a padded cup to support the head. A sterilizable wheel enables the operator to raise and lower the patient's head to whatever height is desired, while lateral movements also can be made.

If the œsophagoscope is to be passed into the lower œsophagus, the patient's head must be depressed : the whole table is then elevated by a foot pump, or is, in addition, tilted so that the operator can see clearly down the œsophagoscope without having to crouch. The mechanical head rest has the further advantage of maintaining the head accurately in the desired position for an indefinite period.

2. **Tubes for examination** include specula for use at the mouth of the œsophagus and tubes for the middle and lower regions. Various lengths and sizes are required for different ages, and a complete set is expensive. The following table gives the dimensions that are most useful :

Size	Outside Diameter	Inside Diameter	Circumference	Length
	mm.	mm.	mm.	cm.
Adult long, full lumen .	18×20	15.6×17.6	60	45
Adult long, medium lumen	14×16	11.6×13.6	48	45
Adult short . . .	16×18	13.6×15.6	55	35
Child	10×12	8.0×10.0	35	35

Specula and œsophagoscopes of Chevalier Jackson's type are illuminated by a small electric bulb placed in a groove near the distal end : those of Brünings, Kahler, and Haslinger have a lamp in the handle, and a mirror to reflect the light along the tube. Negus has introduced tubes in which the illumination is supplied by twin lens-fronted lamps set obliquely into the walls near the proximal end. By this means a powerful light is given, without danger of obscuration by secretions, and with ease of sterilisation and instrumentation.

Œsophagoscopes of Jackson's type are also required, for instance, in congenital short œsophagus when it may be necessary to pass a narrow endoscope through the stricture to inspect the interior of the thoracic stomach. These instruments with their distal lighting are used in two sizes. Negus has modified the Jackson instruments slightly, making them with an expanded upper end and with an attachable proximal projector.

An œsophagoscope, in addition to the features already mentioned, must :—be well-balanced and not unwieldy ; have an unobstructed lumen ; be sufficiently large to hold the œsophagus open and to give a comprehensive view ; be strong enough not to be easily dented by the patient's teeth, and be sterilizable in all its parts.

3. An efficient **suction pump** is required ; the mechanism may be outside the operating theatre or the whole apparatus may be portable, and either electric or dependent on water power. Great care is required with portable electric pumps to avoid ignition of anæsthetic vapour by sparking. Rubber tubing connects the pump to a metal suction tube, either built into the walls of the œsophagoscope or inserted through its lumen. Specially prepared swabs must be at hand to suit the various sized tubes. They are carried on holders of Chevalier Jackson's pattern.

Preparation of the patient.—Before œsophagoscopy the patient should have a general overhaul and also local examination of the nose, pharynx and larynx. A radiographic examination is also essential. If any incision of the œsophageal walls is contemplated strict attention must be paid to the condition of the mouth. Dental sepsis must be eliminated and, before certain operations, all carious teeth should be removed ; if time permits, the remaining teeth may be scaled and made scrupulously clean.

If the œsophagus is much dilated it should be washed out an hour or two before examination, particularly if general anæsthesia is to be employed. A large stomach tube is used, with a funnel through which boracic lotion may be run in and then syphoned back. The condition of patients who are dehydrated as the result of obstruction must first be improved by the administration of fluid, either by rectum or subcutaneously.

Position of patient.—The patient lies down, as this permits greater ease of examination and also avoids irritation of the trachea by over flow of saliva from the pharynx. He is put in the Boyce position that is to say with half the scapula projecting beyond the end of the operating table, the head being supported by a mechanical rest or held by an assistant. (Fig. 699.)

Anæsthesia.—For the majority of œsophageal examinations general anæsthesia is desirable. It is safer if a sharp foreign body is lodged in or near the crico-pharyngeal fold, as restlessness increases the risk of laceration of the œsophageal walls from instrumentation. In cases of malignant stricture general anæsthesia is merciful and is particularly called for if delicate manipulations are to be carried out, when immobility and relaxation are essential.

Local anæsthesia may be employed in certain adult cases, particularly where there is wide dilatation, when general anæsthesia might be accompanied by regurgitation of food débris into the trachea.

In any case a preliminary injection of some sedative is required one hour before operation ; omnopon and scopolamine are recommended in suitable doses according to age and general condition. For an adult the dose is omnopon, gr. ¼, scopolamine, gr. 1/150. This is followed by painting the lips, gums, tongue, pharynx and pyriform fossæ with 10 per cent. cocaine mixed with equal parts of 1 : 1,000 adrenalin ; about 60 to 120 minims of the mixture is required. Dessicane, 2 per cent., may be used, if preferred, but in our experience is not so effective. The part requiring greatest attention is the fossa pyriformis, in which the swab, carried on a long holder, should remain for half a minute. It is important to avoid using any excess of cocaine, for fear of poisoning. The solution recommended causes rapid constriction of superficial capillaries, whereby absorption is avoided ; if any of the solution is swallowed, however, there may be rapid passage through the walls of the stomach, with symptoms of poisoning. The characteristics are : a feeling of faintness, weakness and possibly vomiting and nausea associated with pallor, sweating, rapid breathing, and feebleness of the pulse. The appropriate treatment is to give the patient a diffusible stimulant such as whisky or a drachm of sal

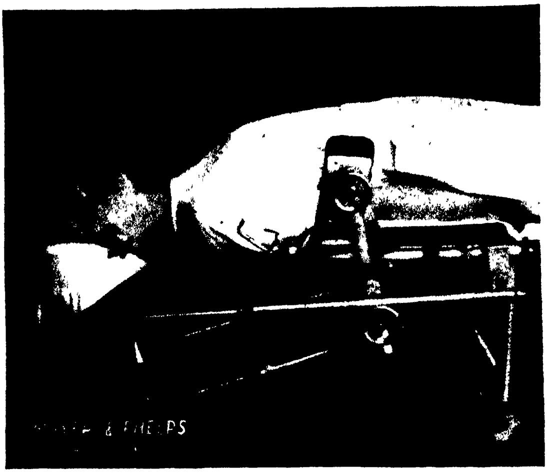


Fig. 699.—Headrest for peroral endoscopy. Position for œsophagoscopy.

volatile in an ounce of water. In severe cases 1 or 2 c.c. of pituitary extract should also be given hypodermically.

General anæsthesia may usefully be preceded by basal anæsthesia in the form of nembutal by mouth or paraldehyde per rectum for children, or avertin for adults, followed by intra-tracheal administration of gas and oxygen, possibly combined with a very small quantity of chloroform. Care and skill are required for this method, but in expert hands the results are most satisfactory. This form of anæsthesia obviates any possibility of explosion.

Technique of œsophagoscopic examinations. **Position.**—The method to be described is that in which the patient lies in the dorsal position with the head supported. The occiput should be 10 cm. above the level of the table. The head must be extended to bring the mouth as nearly as possible into line with the axis of the gullet.

In introducing a speculum or œsophagoscope various landmarks must be identified on the downward passage ; after practice, this can easily be done, so that introduction of the tube into the gullet is carried out with ease and rapidity.

Examination with a speculum.—The whole of the necessary manœuvres are carried out under the guidance of the eye. The instrument, lubricated with liquid paraffin, is held in the left hand and is guided and propelled downward by the fingers of the right hand ; these fingers, at the same time, protect the patient's lips. The instrument is used to inspect the hypopharynx and the upper end of the œsophagus. The tongue is depressed, as with a spatula, and the operator's left hand is lowered until the speculum is almost horizontal ; the top of the epiglottis is thus displayed. It is essential, during this manœuvre, that the patient's head should be well raised to straighten the cervical spine.

The epiglottis is passed and the speculum, with the beak directed forward, is guided into one or other pyriform fossa, preferably the right. To reach this region it is wise to see and identify the upstanding tip of the cartilage of Wrisberg in the ary-epiglottic fold, and to pass outside it. Having entered the right pyriform fossa, the beak of the speculum is directed slightly to the left, while the larynx is, at the same time, lifted forward by pressure of the instrument against the cricoid cartilage. If this manœuvre is carried out accurately, while the speculum is made to slide gently downward—mainly by the action of the thumb and first finger of the right hand—the crico-pharyngeal fold will come into view and will gradually relax to admit the beak of the instrument and thus disclose the lumen of the œsophagus proper, which opens as air enters during inspiration.

Examination with the œsophagoscope.—This is passed in much the same way, except that the tube itself is grasped and not its handle. It is desirable to reverse the procedure just described and to employ the right hand for holding the tube, while the left hand protects the lips and controls onward movement.

Once the œsophagus is entered, a collection of fluid or froth may be seen. The suction apparatus will remove this, but swabbing may also be needed, or lumps of food may require removal with forceps. The curve of the thoracic œsophagus is followed by depressing the patient's head gradually while moving it slightly to the right. In passing through the lower third of the gullet it is necessary to depress the head considerably, taking care to have a clear lumen always in view, with no blind thrusting forward. When the diaphragmatic orifice is reached, the tip of the œsophagoscope should point in the direction

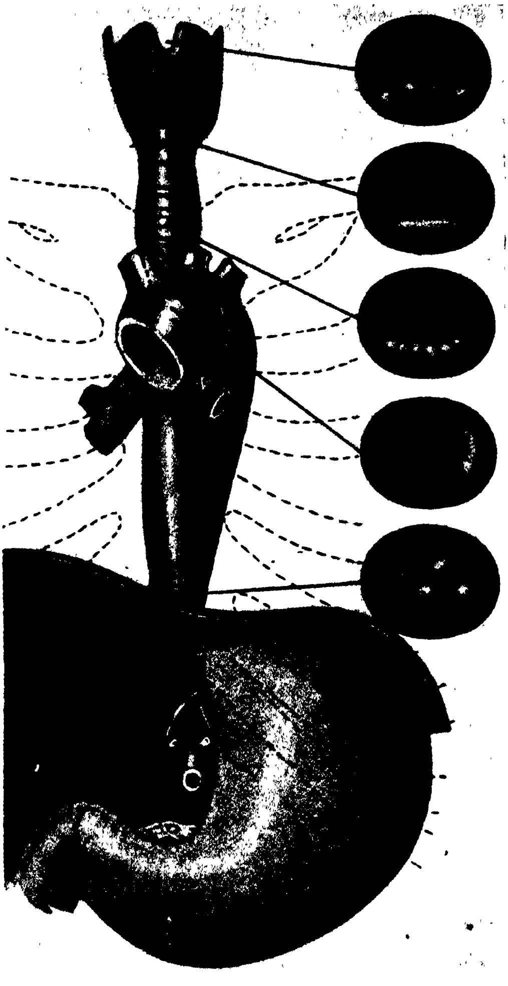


Fig. 700.—Œsophagoscopy : appearances at various levels.

(Reproduced, by permission from Walter Howarth : British Encyclopædia of Medical Practice, Vol. 5, Butterworth & Co.

of the left anterior superior spine of the patient's ilium. The hiatus appears in rosette form and closed, in contradistinction to the lumen of the thoracic œsophagus, which is lax and opens widely during inspiration, partially closing during expiration. (Fig. 700.) A short distance below the level of the diaphragm the œsophagoscope will enter the stomach, the mucosa of which is recognized by its darker pink colour and its well-marked large rugæ.

CHAPTER XXXIII

OPERATIONS ON THE ŒSOPHAGUS

By G. GREY TURNER and V. E. NEGUS

METHODS OF TREATMENT WITH THE ŒSOPHAGOSCOPE

1. **Removal of foreign bodies.**—Swallowed objects lodge in the œsophagus because of their size or their shape and character. Dentures and coins are examples of the former, while among the latter are sharp objects, such as bones and pins. The usual site of impaction is the crico-pharyngeal fold ; next in order of frequency is the level of the thoracic inlet in small children. If an object passes these points of constriction it is likely to slip through the œsophagus into the stomach, but large bodies like tooth plates may be impacted near the crossing of the left bronchus.

The commonest objects are halfpennies ; and the subjects are usually children. Farthings are too small for impaction and pennies too large to be put into the mouth. The coin lies transversely at the mouth of the œsophagus and, if recently swallowed, is readily removed by the direct method, which should present no difficulty with adequate apparatus and some little practice and experience. The removal can be carried out, by one skilled in the art, without any anæsthetic, as the manipulation is little worse than simple depression of the tongue. In nervous or apprehensive subjects, general anæsthesia is preferable, and this should always be used in cases of long standing impaction or with irregular or sharp-pointed objects. In such circumstances complete relaxation of the pharyngeal and œsophageal musculature is essential.

The patient is placed in the position described (p. 1478), with the head raised and extended ; an œsophagoscopal speculum is passed into the mouth and used like a spatula to depress the tongue. In adults who have a full set of front teeth, it may be easier to insert the instrument on one or other side of the tongue, through the angle of the mouth. The beak of the spatula is made to slip behind the larynx, care being taken not to irritate the latter. Secretions are removed by suction or swabbing. The upper edge of the coin will, in all probability, be seen lying transversely and upstanding behind the posterior laryngeal wall. It is grasped with serrated forceps, care being taken to avoid including any mucosa. The beak of the speculum is moved downwards to touch the coin, and the tube and foreign body are then drawn up and removed together.

If the coin has been *in situ* for a long period, that is to say, from four to twelve weeks or more, it is better to use toothed forceps ;

with these the grip is taken just beyond the beading. When traction is applied, the coin is free to rotate to one side or the other, which facilitates disimpaction.

Sharp objects, such as fish or meat bones, present greater difficulties, for they must be disimpacted before removal. The uppermost point is grasped with forceps and is drawn away from the œsophageal wall, while the beak of the speculum may be used to exert counter pressure and to push the wall gently aside. Once the point is freed, removal is simple. Tooth plates, even with hooks, are similarly disimpacted and withdrawn. In certain cases toothed forceps are useful, as they allow the foreign body to rotate into the position most convenient for removal. Forcible contraction of the crico-pharyngeal sphincter may force the œsophageal walls over the point of a sharp bone or pin and may thus cause perforation ; for this reason complete relaxation under general anæsthesia is desirable. Foreign bodies may be hidden in the folds of the œsophagus, but a wide tube with good illumination, used on a relaxed patient, should overcome this difficulty.

Open safety-pins present some problems. The point is located and then grasped with serrated forceps, of a sufficient length to pass easily through the speculum and to protrude far enough beyond its proximal end to allow a comfortable grip with the hand. The beak of the speculum can be used to push the wall of the œsophagus away from the embedded point, by turning the instrument slightly to one side. The sharp point is then pushed downwards sufficiently for disimpaction and brought within the lumen of the tube in the grasp of the forceps. By withdrawing speculum and safety-pin together, it will be found that the keeper, although not protected, will slide easily up the walls of the pharynx. If the pin has passed far into the œsophagus and cannot be removed by this means, it may be necessary to grasp its ring with toothed forceps and then to push it into the stomach, but without releasing the hold of the forceps ; here the pin can turn, to be drawn up with its point trailing. When a foreign body passes through the crico-pharyngeal fold and thoracic inlet and is arrested in the thoracic œsophagus, considerable difficulty may be encountered in removing it. The principles do not vary, however, from those already described.

If an object remains in the œsophagus for a considerable length of time—for instance, a coin *in situ* for three months—the problem of removal is complicated by the presence of granulations, which obscure the picture not only by their size but also because they bleed on touch. So large an object as a halfpenny may be buried, but the solid feel it imparts when touched by the beak of the speculum or the point of the forceps may indicate its whereabouts. Adrenalin, applied to the inflamed surface, by constricting the vessels and diminishing the swelling, may help in revealing the foreign body sufficiently to allow it to be grasped and removed.

After treatment.—Swallowing should be limited to fluids or soft semi-solids like custard. Dry powders of barium sulphate (gr. v) should be tipped on to the back of the tongue every five or six hours, and lozenges of phenol (gr. ½) should be sucked three-hourly.

Complications.—In recent cases little harm may be done if care and skill have been employed in extraction. Sometimes, however, considerable laceration of the œsophageal or pharyngeal walls is caused, particularly if blind attempts at removal have been made by one who is inexperienced or not equipped with suitable apparatus. The umbrella probang and coin catcher in past days led to many such accidents and should be avoided. In extreme cases of trauma a rubber feeding-tube may be passed down the œsophagus and left in place for two or three days, but this does not, of course, prevent the passage of saliva over the raw area.

PERFORATION OF ŒSOPHAGEAL WALLS

Perforation of the **cervical œsophagus** leads to swelling in the neck, from hæmatoma, surgical emphysema, or abscess formation. Free opening by an incision lateral to the trachea is required, if the patient's life is to be saved. The patient lies in the dorsal position with the head somewhat extended and turned to the opposite side.

An incision, 4 ins. in length, is made just in front of the anterior border of the sterno-mastoid and extending from the sterno-clavicular joint to the upper border of the thyroid cartilage. This incision divides skin, superficial fascia and platysma. The deep fascia is then incised in the line of the incision and the anterior border of the sterno-mastoid exposed. The muscle is drawn outwards and, should the external jugular vein be met, it should be drawn aside or divided between ligatures. The omo-hyoid, which crosses the wound, should be divided and the infrahyoid muscles drawn to the inner side. In the depth of the wound the thyroid gland appears on the inner side and the carotid sheath on the outer. The former should be retracted inwards and the latter outwards, and the inferior thyroid artery, which is situated in the lower part of the wound, should either be avoided or be divided between ligatures.

If the abscess is extensive these anatomical structures may be obscured by œdema, and the operation is terminated as soon as the abscess is opened. The foreign body may or may not be found. The wound should be lightly packed with gauze and left widely open. Rarely, the inflammatory process causes sloughing of vessels, arterial or venous. This considerably increases the difficulties of treatment. Ligation of branches, or of the great vessels themselves, may be required.

If there is perforation through the walls of the **thoracic œsophagus** a para-œsophageal abscess will result and may be recognized by the signs of localized mediastinitis, sometimes with characteristic radiographic appearances of air outside the œsophagus. Thoracotomy is not desirable; the correct method of treatment is slitting up the œsophageal wall by a fine, long-handled knife, introduced through a wide œsophagoscope. The œsophagus is thus utilized as a drainage tube. If the pleura has become infected, aspiration or intercostal drainage is necessary.

After-treatment.—The patient is best fed through a tube passed by the mouth into the stomach and kept in position for the first few days after the operation. In very bad cases temporary gastrostomy may be necessary.

In many cases of injury there is no localization, and the serious complication of acute mediastinitis develops at once. This may declare itself almost immediately after the interference or may be delayed for 12 to 24 hours. The symptoms are retro-sternal pain, extreme difficulty in swallowing, high temperature, usually ushered in by a rigor, and profound toxæmia. Physical signs are few, and the most prominent are painful swelling at the root of the neck where the tissues may crepitate. The condition is usually rapidly fatal, though in some few cases there is localization with abscess formation. Treatment must be as for septicæmia, and the sulphonamide group of drugs will play a prominent part. When there is swelling or even tenderness at the root of the neck, a low collar incision should be made through the deep fascia and the finger insinuated backwards and downwards by the side of the trachea and between it and the carotid sheath. When the cellular tissue surrounding the œsophagus is reached, gas or thin sanious infected fluid or horribly fœtid pus may escape. Soft rubber drains must be inserted in the track of the finger and the wound packed with gauze and left open. The patient should be nursed with the foot of the bed raised.

ŒSOPHAGOTOMY

In some few cases foreign bodies have been so long impacted that they cannot be removed endoscopically, or unsuccessful attempts at removal have so injured the œsophageal wall that it is not safe to leave them *in situ*, and open operation is essential. In these circumstances œsophagotomy is indicated. In the great majority of cases the cervical route will suffice, though bodies deeply imbedded in the walls about the middle of the œsophagus may have to be approached by the posterior mediastinal route (p. 1486).

Other indications for œsophagotomy may be the treatment of an intractable form of non-malignant stricture or the removal of some non-malignant tumour which cannot be dealt with endoscopically.

CERVICAL ŒSOPHAGOTOMY

Technique.—The œsophagus is opened in the lower part of the left anterior triangle of the neck (Fig. 701). It is most important that the shoulders should be raised and the neck well extended, with the head turned to the opposite side. The incision is made along the anterior border of the sterno-mastoid from the upper border of the thyroid cartilage to the sterno-clavicular joint. The anterior border of the muscle is defined and cleared and is drawn outwards. The incision is deepened and the anterior belly of the omo-hyoid muscle divided. The middle and inferior thyroid veins must be divided between ligatures. The carotid sheath should be exposed but must not be opened, and it is better not to divide the inferior thyroid artery though that step may be necessary in low-lying lesions. The carotid sheath is gently retracted outwards, and the thyroid, with the trachea and larynx, inwards. In the interval the œsophagus can be reached by blunt dissection. Though it inclines towards the left it is largely hidden by the trachea. The œsophageal wall is recognized by its longitudinal muscular fibres but may be more readily identified by passing a large rubber œsophagus tube from the mouth. Two guide sutures of catgut should be inserted into the œsophageal wall about the middle of the part exposed ; when these are gently drawn up, the œsophagus is lifted up towards the incision. The cellular tissue should be carefully protected by gauze soaked in 1 : 1000 flavine solution. The œsophagus is opened by a very small vertical incision between the guides, and mucus—which will almost certainly be infected—removed with the suction apparatus. The incision is then prolonged to the length of an inch or a little more and, if the foreign body is not found, the finger can be introduced and will usually be able to reach the object. The finger is used first so that if necessary the œsophageal wall may be

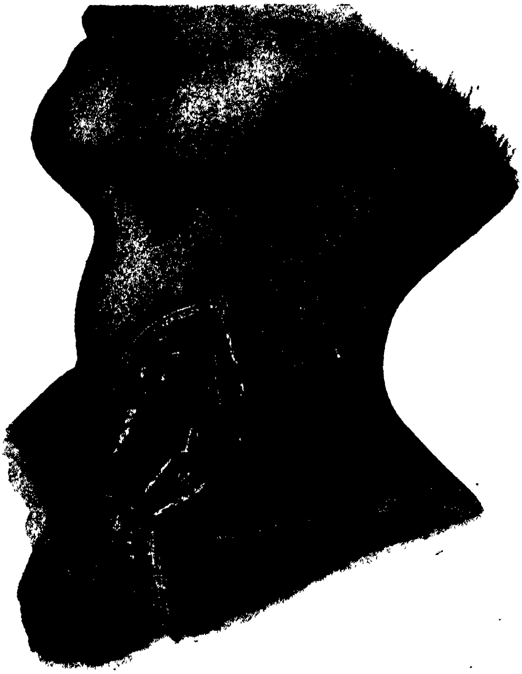


Fig. 701.—Œsophagus exposed at root of neck between trachea and carotid sheath.

gently pushed away from the intruder. A strong reliable pair of forceps may then be introduced and the foreign body grasped. If it cannot be easily withdrawn no force should be used, and it must be coaxed free of the œsophageal wall, which may be disentangled from it with the finger or some blunt flat instrument.

After the removal the area is carefully cleansed and the wall of the œsophagus closed with a continuous suture of 3/0 chromic catgut passed through the mucous membrane and the submucous coats, if they can be separately identified. This stitch must be hæmostatic and watertight. After further cleansing of the œsophageal wall this first stitch is buried by a series of interrupted sutures of catgut drawing the muscular layers together. These stitches must not be too tight or they will cut through the muscle. It is a good plan to smear a little sulphanilamide or Bipp over the suture line. The guide sutures are now withdrawn and the œsophagus allowed to slip back into its normal position. The protecting gauze is removed from the wound. A very soft rubber tube or a strand of rubber tissue about the size of a little finger is brought from the depths out through the incision and by the most direct route to the surface. No deep sutures are inserted, but the platysma and skin are carefully drawn together leaving ample room for the drain. If the œsophageal wall is inflamed and friable, no attempt should be made to close it by suture, though the edges of the incision may perhaps be approximated. In these circumstances the whole wound should be left open and packed with gauze. A voluminous dressing is applied to act as a splint for the neck.

After-treatment.—The patient must be nursed lying flat or, if there is evidence of severe infection, with the foot end of the bed raised. Only very small quantities of liquid are allowed by the mouth for the first day or two, nutrition being largely supplied by the rectal or intravenous routes. Any gauze pack which has been used must be left untouched for 48 hours and then only gradually removed. Rubber drains should remain for a week. The further particulars of the after-care and possible complications are described on p. 1488.

POSTERIOR MEDIASTINAL ŒSOPHAGOTOMY

When the foreign body is firmly impacted at or below the level of the arch of the aorta it is unlikely that it will be possible to remove it safely from even a low cervical œsophagotomy. In such circumstances the thoracic œsophagus must be attacked. This is quite a feasible operation, though inseparable from the dangers always associated with opening up the cellular tissue of the mediastinum. The depth of the œsophagus from the posterior surface of the body is greater than is often appreciated, and can best be realized by a study of life-size transverse sections of the trunk. (Fig. 697.) Patients for whom this operation is required are usually in very poor condition and may have some difficulty in swallowing so that preliminary gastrostomy is generally wise, though not always essential. The operation on the œsophagus should not be contemplated until full benefit has been obtained from careful feeding and pre-operative care.

Technique.—Since the position of foreign bodies can be accurately determined, the incision should be made over the area of impaction and on the left side. With the patient lying half over on the right side, an incision from the middle line of the back is extended forwards for 6 or 8 inches along the line of the rib opposite the site to be exposed. In bulky or muscular subjects a vertical incision at the outer border of the erector spinæ should be combined with the incision along the rib. The incision must divide the muscles down to the ribs. By drawing the edges of the skin and muscle apart, three ribs can be exposed. These are carefully cleared just at and behind their angles. If the ribs are not very close together it may be possible to pass the finger beneath the lower border and to insinuate it into the cellular tissue between the deep surface of the rib and the pleura. The finger is passed gently upwards, downwards and inwards deep to the neighbouring ribs, mobilizing the pleura and allowing it to sag away from the area. Portions of three ribs are then removed from a point just anterior to their angles as far back as their articulation with the vertebræ. By the use of a rib spreader at this stage a sufficient space will usually be secured but, if more room is required, it may be obtained by removing a considerable portion of one or more ribs above and below.

It will now be wise to infiltrate the cellular tissue with several ounces of weak local anæsthetic (0·5 per cent. novocain). This opens up the cellular tissue and facilitates the separation of the pleura. With the gentlest possible manipulation, either with the finger or a small gauze mop, the pleura is thrust away from the parietes. Very often there has been some mediastinitis so that the pleura is adherent. In these circumstances, it is very difficult to avoid injury and admittedly it is frequently torn. With intra-tracheal anæsthesia, or even without, there are no serious symptoms from collapse of the lung when the patient is in the semi-prone position. As a rule it is very difficult to repair the rent in the pleura at this stage of the operation and in any event, once broken, the pleura is apt to be further torn. It is as well to make a virtue out of necessity and to utilize the rent to explore the œsophageal condition, and then temporarily to pack the rent, or the pleural cavity, with gauze soaked in 1 : 1000 flavine solution until the œsophagus has been dealt with.

As the pleura is stripped forwards and inwards, the aorta will probably be the first recognizable structure to be exposed and its relation to the œsophagus varies with the level. The œsophagus must be reached by working in front of the aorta. As a rule it is readily identified by its well-marked external longitudinal muscular fibres, but these may be obscured by œdema if there is much local inflammatory change. If there is difficulty in identification it will be some help to pass a full-sized œsophageal tube or bougie from the mouth. In the absence of inflammatory changes it is usually easy to separate the œsophagus from the cellular tissue in which it lies and, if it is surrounded with a tape or a ring forceps, this mobilization enables it to be drawn a little towards the surface. When the position of the foreign body has been identified, the œsophagus near it should be fixed between stay sutures of catgut or silk.

A longitudinal incision over the foreign body is made, just large enough to enable the surgeon to coax it out without much traumatism, for the inflamed œsophagus is very friable and is easily torn right across.

After removal of the object, the incision in the gullet should be closed, either as described on p. 1486 or with interrupted sutures of catgut. With a friable wall close suture is almost impossible, and it is wiser merely to approximate the edges of the incision. If there is any loose cellular tissue in the vicinity it may be fixed over the sutured area.

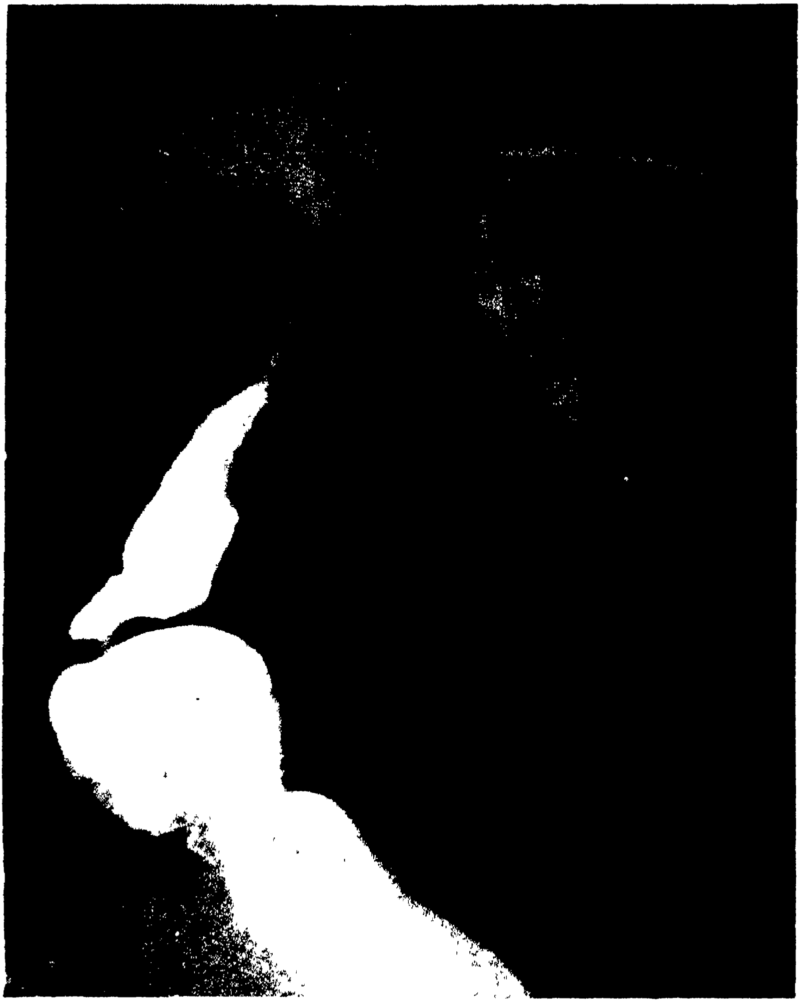
It is essential that a tube should be anchored near the incision but gauze must not be laid in contact with the sutured œsophagus lest the union be torn away during its removal. But the area around the drain-tube should be gently packed with fluffy gauze to provide an ample track to the surface. If the parts are obviously very septic, they should be lightly smeared with Bipp or sulphanilamide applied with the finger. Now is the stage at which to attempt to repair any hole in the pleura by suture or to pack such a tear with gauze. The parietes are then repaired in layers, taking especial care to leave an ample space for the drains by the most direct route to the surface.

After-treatment.—The patient should be nursed on the back to assist drainage. The gauze should not be removed sooner than the fourth day, and the tube at the end of a week or ten days. The after-care for feeding is described on p. 1486.

Complications.—In some of these cases there is a fistula between the œsophagus and some part of the bronchial tree ; this will almost certainly heal after removal of the foreign body unless a complicating fibrous stricture develops at the site of impaction. The latter should be anticipated by the use of weighted bougies passed at the end of about a fortnight. A fully-developed stenosis must be treated as described later (see p. 1492).

There may be many difficulties in this operation but the essentials are a good exposure, good hæmostasis and adequate illumination. It should be a deliberate orderly proceeding, conducted without haste, and modified according to the conditions found and the difficulties encountered.

It must be reiterated that, if swallowed foreign bodies are dealt with by experts in direct endoscopy working in properly-equipped clinics, none should require removal by the external route. The only exceptions may be those which have perforated the œsophageal walls before arrival at a proper clinic.



The radiograph shows a moderately dilated œsophagus, with a stricture where the shortened œsophagus joins an intrathoracic stomach. The latter is considerably dilated and communicates with the abdominal portion of the stomach through a dilated diaphragmatic opening. The patient was a lady aged sixty, who had suffered from flatulent indigestion all her life. The cause of her symptoms was not discovered until severe gastric pain and vomiting necessitated a radiographic examination.

(*Reproduced, by permission, from Thompson and Negus: Diseases of the Nose and Throat*)

CONGENITAL SHORTENING OF ŒSOPHAGUS

PLATE VI.

ABNORMALITIES

1. CONGENITAL

a. **Complete imperforation.**—This condition declares itself within 24 hours of birth and is rapidly fatal, not entirely from starvation but partly from inflammatory lung changes, the result of aspiration of milk into the bronchial tree. If expert assistance is available the œsophagoscope should be used in the hope that some small channel may be found which can be dilated or intubated. Chevalier Jackson has divided short webs with success. If this is impossible, gastrostomy should be carried out as the only life-saving measure available. In most of these infants the upper end of the lower part of the œsophagus communicates directly with the trachea, so that food given by the gastrostomy is almost certain to regurgitate into the lungs, and cause death from inflammatory troubles. For this reason an occluding ligature should be tied around the abdominal œsophagus when the gastrostomy is made. If the child survives, a direct attack may be made on the site of deformity, using the trans-thoracic approach.

b. **A partial web,** discovered in later life, may be stretched or broken down, or divided by the diathermy needle. Such webs usually occur at the level of the crico-pharyngeal fold but occasionally at the diaphragmatic hiatus.

c. **Congenital strictures** may only produce very mild symptoms in infancy or childhood, but tend to get worse later in life. Their treatment is that of simple stenosis (see p. 1492).

d. **Congenital shortening of the œsophagus.**—This condition has been brought into prominence in recent years through the writings of Brown Kelly, Leonard Finlay and Sir Thomas Dunhill. The condition accounts for many cases of dysphagia in which the cause was previously undiagnosed. The œsophagus ends several centimetres above the level of the diaphragmatic hiatus, usually at about the seventh thoracic vertebra. In some cases, not only does the lowest segment fail to elongate, but its lumen may also be deficient and fail to open out as growth proceeds. Furthermore, there may be some defect in the normal epithelial lining, so that the walls are open to spread of infection from the lumen, with resulting infiltration and fibrosis.

The deficiency of the œsophagus in length is compensated by elongation of the stomach, which reaches above the diaphragm, thus being sub-divided into thoracic and abdominal segments, communicating by a wide opening through the diaphragm (Plate VI).

Symptoms.—Three types of symptom may arise and each must receive appropriate treatment. The three types may appear singly or in combination.

In the first type *dysphagia* is the leading symptom. This is the result of a stricture at the junction of the œsophagus and stomach, either from developmental defect or from secondary fibrosis. Such a condition may be associated with regurgitation of food. The first line of treatment is the same as that advised for non-malignant stenosis, and it will have to be repeated according to the necessities of the case. In intractable cases, gastrostomy is required, with subsequent retrograde dilatation as described on page 1495. Eventually gastrostomy feeding will no longer be required, but the opening into the stomach should still be maintained by retaining the rubber catheter or a plug in the stomach until the necessity for further dilatation has ceased.

The second type of symptom is *regurgitation of food* into the mouth, due to stagnation in the œsophagus, or regurgitation of acid secretions from the thoracic stomach, causing ulceration. When the latter occurs there may be severe pain on swallowing, either retro-sternal or referred along the left lower ribs. For the most part the treatment here is medical and not operative. Barium sulphate (gr. 5) or other alkaline powders are given and the patient is advised to sleep sitting up, so that gravity may help to prevent regurgitation from the stomach.

The third complaint may be a feeling of *fullness* in the lower thorax or a sensation of intra-thoracic pressure, and there may be attacks simulating angina. These symptoms are due to distension of the thoracic stomach with food or gas, and they may be relieved by dividing the left phrenic nerve in the neck, which presumably does away with any part that diaphragmatic contraction plays in their causation.

Operation.—It may be possible to mobilize the stomach as it passes through the diaphragm and to bring the thoracic segment down into the abdomen. Or, if there is extreme dilatation with kinking, anastomosis may be established between the abdominal and thoracic portions of the stomach. This operation is in all respects similar to œsophago-gastrostomy but will probably have to be conducted by the trans-thoracic route.

2. ACQUIRED ABNORMALITIES

Pharyngeal diverticula cause symptoms of œsophageal obstruction and are described at p. 1432; *pouches* in the lower œsophagus also occur. (Plate VII.) Œsophageal pouches may be caused either by pulsion or traction and may be present without producing symptoms, or may be associated with some degree of œsophageal obstruction. Investigation may show some narrowing of the gullet at the site of origin of the pouch, or the symptoms may result from the intermittent over-filling of the pouch, as in the pharyngeal variety. Probably some such pouches are congenital but have not caused symptoms until the development of malignant disease in the œsophagus beyond. This combination must always be borne in mind. Any concomitant stenosis of the œsophagus can be treated as in other examples of simple stenosis. Pouches which give trouble by overfilling may cause serious inanition and require treatment. Gastrostomy ensures against starvation but

The patient, a woman of fifty-two, suffered from intermittent difficulty in swallowing for five years.

(*Reproduced, by permission, from The British Encyclopædia of Medical Practice, Butterworth*)

DIVERTICULUM OF THORACIC ŒSOPHAGUS

PLATE VII.

it may have to be permanent and is not ideal; nevertheless it should always precede direct surgical intervention on the pouch.

Anastomosis to stomach.—Very large pouches have been anastomosed to the cardiac end of the stomach, with good results. This operation may be carried out by the transthoracic route on the left side. The cupola of the diaphragm is incised, and the cardiac end of the stomach drawn up into the chest, when the anastomosis can be made by direct suture between the pouch and the stomach. In this operation it is essential to empty the œsophageal pouch through the œsophagoscope as a preliminary to operation.

The same operation may be done in two stages. The first consists of transpleural exposure of the œsophagus with the pouch, and crushing the phrenic nerve as it passes down the lateral wall of the pericardium. The diaphragm is incised and a cone of the fundus of the stomach is drawn into the chest cavity and its base sutured to the edges of the diaphragmatic incision. The œsophageal pouch and the cone of stomach are sutured together, but without opening the mucous membrane, and the chest is closed. Three or four weeks later the chest is re-opened and the anastomosis completed. The anastomosis is made by direct suture and the opening must be large enough to admit two fingers.

When the fundus of a large diverticulum extends right down to the bottom of the pleural cavity it may be possible to carry out the anastomosis from the abdomen. Whether it will suffice to enlarge the œsophageal hiatus, so that the fundus of the diverticulum can be drawn down and approximated to the stomach, or whether an independent incision of the diaphragm will be necessary, depends on circumstances. Every case must be carefully and independently studied.

When the diverticulum arises from about the middle of the œsophagus or higher it will probably not be feasible to make an anastomosis and other modes of relief must be considered.

Removal of pouch.—Pouches of moderate size may cause very marked symptoms and in such circumstances the question of their removal properly arises. It must be realized that any direct interference with the mediastinal œsophagus is, as yet, a serious intervention and that pouches unassociated with malignant disease are not lethal and can be palliated indefinitely, sometimes by dilatation of the œsophagus at their site of origin, and certainly by gastrostomy. If the surgeon decides to intervene, the patient should be got into good general condition, preliminary gastrostomy being performed. The pouch should be emptied of decomposing and probably septic contents before the approach. The exposure may be by the posterior mediastinal route, as described in posterior mediastinal œsophagotomy (p. 1486), or by the trans-thoracic route which gives more latitude (p. 1514). The empty pouch may be difficult to identify, and during the operation all should be in readiness for the passage by the mouth of the illuminated œsophagoscope. The pouch, having been identified and thoroughly mobilized right up to the point of its attachment to the œsophagus, may be excised, invaginated into the œsophagus, turned upside down and fixed in that position, or its extremity anastomosed to the œsophagus lower down. Which of these plans is to be adopted will depend as much on the experience of the operator as on the local conditions. If excision is selected, the surgeon must take care not to constrict the œsophagus at the site of removal. After proper exposure the technical steps of removal are the same as those for pharyngeal pouches. (p. 1482).

INFLAMMATORY DISEASES

CHRONIC HYPOPHARYNGITIS

This is a condition of considerable surgical importance, owing to its relationship to post-cricoid carcinoma. It is an inflammation of a particularly chronic type affecting the mouth of the œsophagus and, in particular, the pharyngeal aspect of the crico-pharyngeal fold. Descriptions of the disease were given some years ago by Paterson and Brown Kelly. The condition is somewhat similar to chronic superficial streptococcal glossitis, of which the cause is said to be sub-epithelial growth of streptococci (French). The two frequently appear in conjunction, sometimes with secondary anæmia; the conjunction of these three signs—dysphagia, glossitis and anæmia—is often referred to as the Plummer-Vinson or, more correctly, Paterson-Brown Kelly syndrome. Occasionally the angles of the mouth and palate are chronically inflamed in a similar manner. Gradually increasing dysphagia is produced by infiltration of the mucosa at the mouth of the œsophagus. The inflammation is of an atrophic type, with glazing, superficial ulceration, and subsequent healing with scar formation. Contraction leads to narrowing of the mouth of the gullet.

Treatment.—Treatment consists of periodical dilatation with flexible bougies or a bag, passed under direct vision. If webs have formed, they must first be ruptured by forceps or by the wedge-like effect of an œsophageal speculum, gently insinuated. Large doses of iron should be given if anæmia is present. Many cases of carcinoma have been known to arise as a sequela of this chronic inflammatory process, and careful watch must therefore be kept, in order to institute treatment of such a growth in its early stages. It is considered justifiable to treat severe cases by excision of the region and plastic reconstruction, even before definite malignant disease can be detected. Gastrostomy may be required as a preliminary.

STENOSIS

Cicatricial stenosis may follow the swallowing of corrosives, or, occasionally, acute inflammation, or may arise from a variety of rarer causes. Amongst these are long-standing impaction of a foreign body, peptic ulceration, and chronic inflammation at the crico-pharyngeal fold. A similar condition occurs in some cases of congenitally short œsophagus. In all cases dilatation through the mouth should first be attempted and, with skill and perseverance, will usually be successful.

Dilatation can be carried out (*a*) from above, by passage of bougies or by distension with a dilatable bag, under direct vision through an œsophagoscope ; (*b*) by dilation with bougies or a bag under fluoroscopic guidance (Mosher) ; (*c*) by gradual dilatation with bougies passed blindly, either by the medical practitioner or the patient ; (*d*) by the thread-guided method (Plummer) ; or (*e*) by retrograde dilatation (Gabriel Tucker).

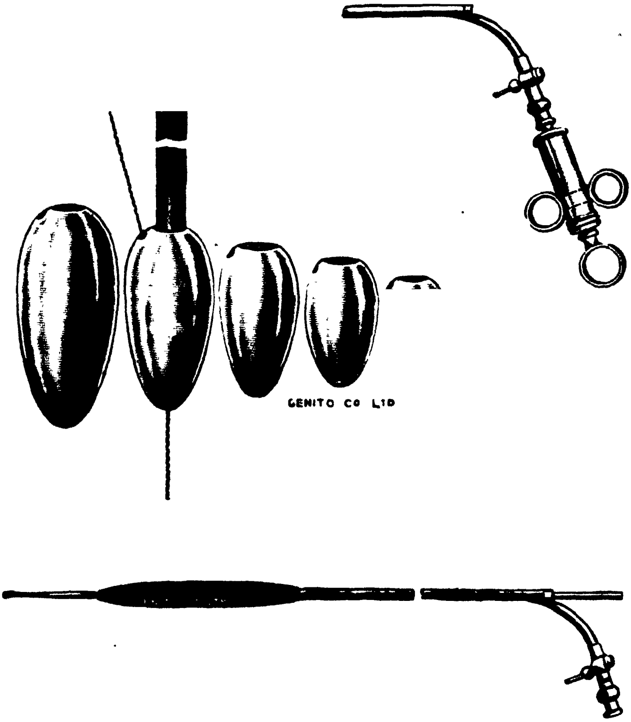


Fig. 702.—Dilating bags and bougies. The top figure shows a conical bag for distension with water ; the lower figure the guide along which the bag is passed ; the middle figure shows thread-guided olivary bougies carried on a flexible staff.

(*a*) **Bougies.**—The passing of bougies under the guidance of direct vision is easy for those practised in endoscopy, if a wide and well-illuminated œsophagoscope be used. The stricture is exposed and secretions are removed by suction and swabbing. The lumen may be to one side, but gentle search will generally secure entrance for the tip of a flexible dilator, dipped in liquid paraffin. Graduated sizes are introduced in succession, until the lumen is brought up to a calibre sufficient to allow food to pass freely. Other strictures may be found below the uppermost ones, and they too will require dilatation.

Once the lumen of the stenosis has been negotiated with a bougie, a small rubber bag may be used, carried on a flexible hollow stem attached to a thin metal tube. (Fig. 702.) The flexibility of the instrument allows it to pass easily through a narrow stricture, and it can then be dilated with water introduced by a syringe so as to exert a stretching effect. The pressure is regulated by the hand. When the lumen has been enlarged sufficiently, a larger and longer dilatable bag may be passed and distended. The dilatation may have to be repeated after a month, and subsequently at longer intervals until swallowing powers are satisfactory. Treatment over two years or more may be required, particularly for multiple strictures.

(*b*) **Radiographically-guided bags.**—An elongated bag made of silk and rubber may be passed through the stricture under fluoroscopic guidance. For this purpose, longitudinal stripes of barium are painted on the bag, so as to reveal its downward passage and position (Mosher). Cocainisation of the throat is required, but no other anæsthetic is necessary. When the bag is *in situ* it is distended under hand-regulated pressure.

(*c*) **Blind bougies.**—The blind passage of bougies has fallen into general disfavour, because of reports of numerous accidents. These have occurred mainly in cases of carcinoma. One of us (G.G.T.) has, however, used blind bougies with notable success where other measures have failed. Gentleness and care are required, and the patient's sensation of pain must be used to give indication of danger. The method is simple and often effective, but is reserved for selected cases to be treated with due precaution. The main point is to teach the patient to swallow the bougie ; when it is caught in the narrowing it may be advanced by very gentle manipulation, at first by the surgeon and later, when confidence has been established, by the patient.

The type used is the gum elastic bougie of French manufacture softened by immersion in hot water. When the stenosis has been reasonably dilated it may sometimes be kept patent by using Hurst's mercury filled bougies, with which there is little danger. During the treatment the patient should persevere with semi-solid and, as soon as possible, with solid food, as each bolus acts as a dilator.*

(*d*) **Thread guides.**—The thread-guided method is of particular use where there is great difficulty in getting any instrument through the stricture. It is sometimes effective where bouginage under direct vision has failed. The patient must swallow a length of silk thread (button-hole twist No. 5), and for this purpose is given six yards wound on a small spool of cardboard. The end is placed in the mouth with a sufficient length of slack to give play without tangling. By swallowing efforts, possibly assisted by drinking, the thread usually manages to find a way through the stenosis. When the part in the mouth has disappeared down the gullet, a further length of slack is paid out, and so on until between four or five yards have been swallowed.

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* *Grey Turner, Brit. Journ. Surg.*, 1939, xxvi, 555.

The thread will then be anchored firmly in the small intestine and can be pulled taut. A small olivary bougie, mounted on a whalebone staff and with a smooth hole bored through its bulbous end, is threaded on to the line and guided into the œsophagus (Figs. 702 and 703). Holding the line taut in one hand and the flexible staff in the other, the surgeon gently guides the bougie to the stricture in the hope that it may be small enough to slip through. All that the thread can do is to guide the bougie to the site and face of the stricture, and only the gentlest manipulations must be used in negotiating it through the narrowed part. Subsequently, larger bougies are passed at intervals of 24 hours or more.

(*e*) **Retrograde dilation (Tucker's method).**— This technique is only possible where gastrostomy has been performed. A swallowed thread is fished out from the stomach and by it a flexible bougie, or a graduated chain of glass or metal beads, is drawn up through the narrowing and out by the mouth. A thread must be allowed to remain *in situ* so that the dilatation can be repeated until the stenosis is overcome. This happy state may not be attained for several weeks. Tucker uses a long, tapered, flexible, rubber bougie moulded on a silk thread ; graduated sizes are made. An alternative is the use of beads or bobbins starting with a small size and gradually increasing. When the stenosis has in this way become negotiable, treatment can be continued by bougies passed from the mouth.

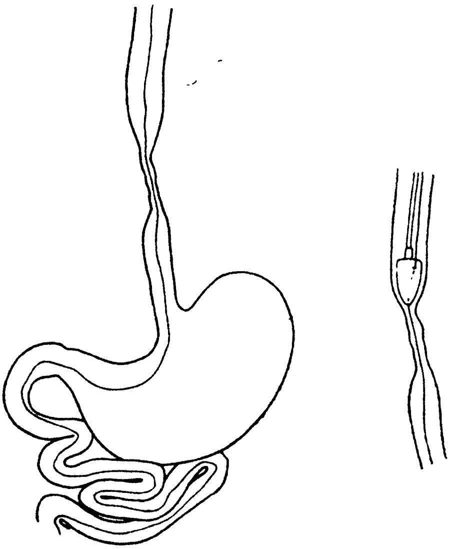

Fig. 703.—A swallowed silk thread used as a guide for the passage of an œsophageal bougie. The figure on the right shows an olivary bougie mounted on the thread and thereby guided to the mouth of the stricture (Vinson's method).

In the few cases in which these methods are not successful other methods may be required. These are :—(1) division by diathermy current through the œsophagoscope ; (2) retrograde dilation through gastrotomy (Fig. 704) ; (3) direct exposure of the strictured area for the purpose of (*a*) plastic enlargement, (*b*) excision with anastomosis ; (4) application of the principle of short circuiting by (*a*) anastomosis of the dilated œsophagus above the stricture with the stomach below ; (*b*) formation of an antethoracic-œsophagus or (*c*) by bridging the gap between a cervical fistula and a gastrostomy with a rubber tube.

Division by the diathermy current.—In practice this method has proved dangerous and has been followed by development of fistulæ into the trachea or bronchus, or death from perforation and mediastinitis. It should, therefore, never be employed.

Dilation from below.—It is not always possible to carry out Tucker's method, and retrograde dilation with bougies introduced from below may have to be employed after gastrotomy. The stomach is exposed, after laparotomy, and its cavity opened. If the incision is placed about the middle of the body of the viscus it is often very difficult or almost impossible to guide the bougie into the œsophagus, but if the opening is just below the cardia the bougie slips in without trouble (Fig. 704). Some strictures which prove completely impermeable from above can be readily dilated in this way. The size of bougie which can just be passed through readily should be advanced until it appears in the mouth. A rubber tube is then slipped well over its point and tied in position and the bougie is withdrawn from the stomach carrying the rubber tube which is disengaged from the bougie and left in the strictured area. Patients resent the tube and may either attempt to pull it out or displace it by retching. For this reason, one end should be attached to the stomach wall by a suture of chromicized catgut and the other should project some distance from the mouth. The incision in the stomach is carefully closed by suture. In from 2 to 4 days the fixation stitch will have loosened and the rubber tube may be with-

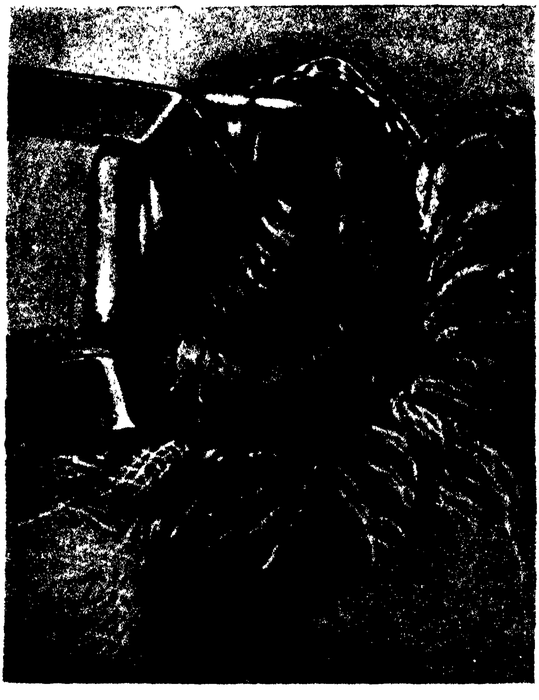

Fig. 704.—**Retograde dilatation through incision near cardia.**

drawn from the mouth and treatment by oral bougies continued. Cases in which the stricture appeared to be impermeable and proved quite unmanageable have been successfully dealt with by this means.*

Plastic enlargement.—The plastic measures for stricture of the œsophagus follow the same plan as the operation of pyloroplasty. This principle has several times been used in dealing with stenosis at the cardiac end of the stomach and is described on p. 1532. It is also occasionally applicable to the cervical œsophagus.†

Excision.—Excision of a strictured area can only be feasible when such an area is of very limited extent, as the longitudinal tension of the œsophagus does not admit of ends being brought together to bridge a wide gap. In other circumstances the diaphragm may be incised and the fundus of the stomach displaced into the chest. The divided œsophagus is then united, end to side, to an opening made in the cone of stomach. This plan has recently met with success.‡ There must be very few cases in which this method is necessary or justifiable for non-malignant conditions.

Short - circuiting.—The principle of short-circuiting may be used with an impermeable stricture or an obliteration at the lower end of the gullet (p. 1533). The other application of this principle is in the formation of an extra-thoracic œsophagus.

CONSTRUCTION OF EXTRA-THORACIC ŒSOPHAGUS

The formation of a new gullet is a problem which seems to have been first tackled by Bircher in 1984, but it was not until 1907 that Roux, of Lausanne, was able to report a completely successful case.§ In that instance the new œsophagus was made of an isolated loop of small intestine which was carried up in a subcutaneous tunnel in front of the thorax. The intestine was united at the lower end to the stomach and at the upper end to the cervical œsophagus. Since that time great ingenuity has been displayed on the problem and many different methods have been devised and tried, with very many failures but nevertheless an encouraging degree of success. The most generally successful plan has been that in which the greater part of the new gullet is made from the skin of the front of the chest, and the lower part from an isolated loop of upper small intestine. The upper end of the skin tube is united to the lower end of the cervical œsophagus or a cervical œsophageal fistula by a plastic operation. This is the jejuno-dermato-œsophagoplasty of Lexer and is the method which will be shortly described. (Fig. 705.)

A new gullet can only be constructed by a series of rather complicated operations extending over some months and associated with considerable risk (35 per cent. mortality) and probably many disappointments. For these reasons the plan should never be attempted until every other method of treatment aimed at the restoration of the normal channel has been perseveringly tried. It ought to be stated that many attempts have also been made to repair or reconstruct a portion of the œsophagus in its normal situation. Most of these have been carried out on the cervical œsophagus where skin flaps have been used with considerable success (p. 1509 and Fig. 712). The same method has been employed in the posterior mediastinum for the thoracic œsophagus, and at least once with success (Lilienthal). Others have endeavoured to reconstruct the lower part of the œsophagus within the thorax either with a loop of isolated bowel or with a new mucous-lined tube made from the greater curvature of the stomach (Ogilvie).* The different methods based on a study of 24 cases will be found described in a paper by Ochsner and Ownes.†

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* *Grey Turner, Brit. Journ. Surg.*, 1940, xxviii, 110.

‡ *R. C. Brock, Brit. Journ. Surg.*, 1942, xxx, 118.

§ *Sem. méd.*, 1907, xxvii, 37.

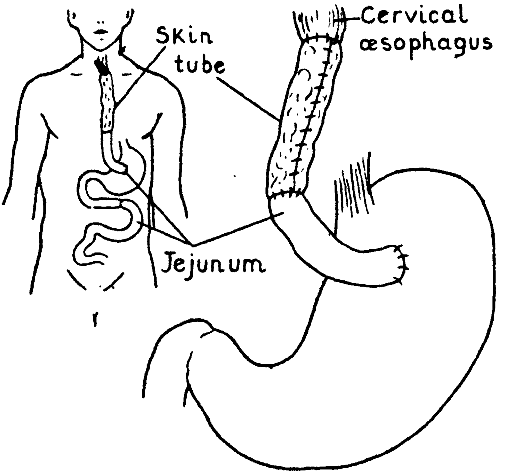

Fig. 705.—**Jejuno-dermato-œsophagoplasty of Lexer** (redrawn from Alton Ochsner).

Technique.—The series of operations required in œsophagoplasty should never be undertaken until the patient is in the best possible state of nutrition which can be secured. A preliminary gastrostomy will always be necessary. Some advise that when a new gullet is in contemplation the gastrostomy should be made with a tube of stomach wall (Janeway or Beck-Jianu) or with a piece of isolated jejunum (Tavel) so that it may afterwards be connected directly to an antethoracic skin tube. The problem varies a good deal, depending upon whether or not a cervical œsophageal fistula already exists. When the thoracic œsophagus has been removed (Grey Turner—Fischer—Kidd) the lower end of the cervical œsophagus will open on to the skin just above or below the clavicle (Fig. 706).

When the whole œsophagus is intact, as in cases of impermeable fibrous stricture, and a functioning gastrostomy has already been made, the operation is best divided into four principal stages :

1. The formation of a cervical œsophageal fistula.
2. The making of an ante-thoracic skin tube.
3. The construction of the lower portion of the new gullet, either with an isolated loop of jejunum or by a Janeway or Beck-Jianu gastrostomy.
4. The union of the upper end of the ante-thoracic skin tube to the cervical fistula.

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* *Brit. Journ. Surg.*, 1938, xxvi, 10.

† " Antethoracic Oesophagoplasty for impermeable stricture of the Oesophagus," *Ann. Surg.*, Dec., 1934, c, 1055

These are the principal stages, but secondary fistulæ at the points of union of the tubes often occur and in most cases supplementary operations are required for their repair.

First stage : the formation of a cervical œsophageal fistula.—This should always be done first because, unless it can be satisfactorily accomplished, the other stages are useless. Furthermore it may prove the most dangerous part of the operation and for that reason it is better that it should be safely accomplished before the other steps are undertaken. There is the further advantage that a cervical fistula can be connected to the gastrostomy by a rubber tube so that the patient may have the advantage of mouth feeding while the other stages of the reconstruction are in progress.

Some surgeons advise that the formation of the skin tube should be the first stage and the construction of the lower œsophagus from the jejunum the next, while as a last stage the cervical œsophagus should be exposed and joined to the skin tube at one sitting. By adopting this order, they hope to avoid the risks of infection from the cervical fistula during the subsequent stages

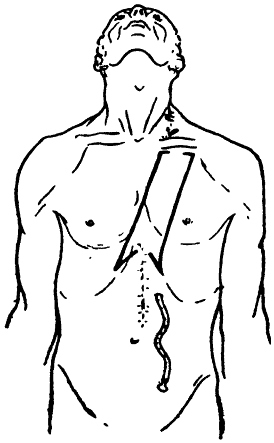
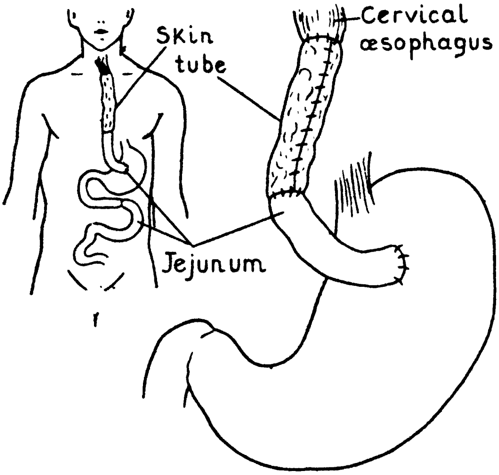


Fig. 706. –Œsophagoplasty by the method shown in Fig. 705. The thoracic œsophagus has been removed, and there is a cervico-œsophageal fistula just above the clavicle and a gastrostomy. The incisions for making the skin tube are indicated.

In any event, it is essential to determine that the cervical œsophagus is patent and healthy, and this will usually require direct observation through the œsophagoscope. There is some question whether it is better to expose and divide the œsophagus in the neck or to make a lateral œsophageal fistula as in the operation of œsophagostomy. The latter operation is not very satisfactory and, if the neck is bulky and the œsophagus deeply situated, the operator will have difficulty in bringing it without tension to the skin surface, where it ought to be fixed by suture to diminish the risk of stenosis developing after the junction of the resulting fistula to the skin tube. There is also said to be a risk that food may collect between the lateral fistula and the œsophageal stricture, the accumulation dilating the remnant of œsophagus and overflowing into the new one.

But the method of œsophagostomy does diminish the risks of infection of the mediastinum after division of the œsophagus. The plan adopted will depend on the circumstances of the individual case. When it can be done the best method is to divide the œsophagus and to bring the upper end out on to the surface where it unites to the skin and forms a fistula just above the clavicle. The œsophagus is exposed as in the operation for œsophagotomy and is separated from its bed by blunt dissection with the fingers. As it is necessary to secure as long a portion of œsophagus as possible to lie without tension above the stated that many attempts have also been made to repair or reconstruct a portion of the œsophagus in its normal situation. Most of these have been carried out on the cervical œsophagus where skin flaps have been used with considerable success (p. 1509 and Fig. 712). The same method has been employed in the posterior mediastinum for the thoracic œsophagus, and at least once with success (Lilienthal). Others have endeavoured to reconstruct the lower part of the œsophagus within the thorax either with a loop of isolated bowel or with a new mucous-lined tube made from the greater curvature of the stomach (Ogilvie).*



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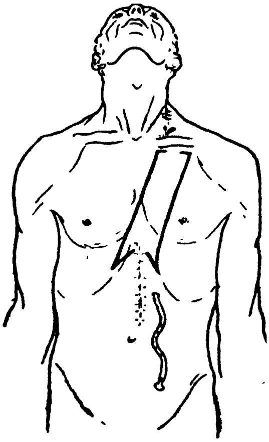

Fig. 706.—Œsophagoplasty by the method shown in Fig. 705. The thoracic œsophagus has been removed, and there is a cervico-œsophageal fistula just above the clavicle and a gastrostomy. The incisions for making the skin tube are indicated.

But the method of œsophagostomy does diminish the risks of infection of the mediastinum after division of the œsophagus. The plan adopted will depend on the circumstances of the individual case. When it can be done the best method is to divide the œsophagus and to bring the upper end out on to the surface where it unites to the skin and forms a fistula just above the clavicle. The œsophagus is exposed as in the operation for œsophagotomy and is separated from its bed by blunt dissection with the fingers. As it is necessary to secure as long a portion of œsophagus as possible to lie without tension above the clavicle, or even to reach to a point just below it, the division must be made as low in the neck as can be managed.

After careful mobilization the œsophagus may be surrounded by a tape or ring forceps which provides a convenient method of manipulation. A strong (No. 3 chromic) catgut ligature is then passed around the isolated œsophagus as low as possible and tightly tied. The lower end of the upper portion may be temporarily occluded by a light clamp or it may be held with forceps or a catgut guide, the tissues around it being carefully protected by gauze from any leakage. The actual division is made with the diathermy or other cautery and must not be too near the ligature lest the retractile muscle of the lower end slip out of the grasp when the tension is relaxed. The cut end should be smeared with Bipp and a fine rubber tube anchored to it, after which it is allowed to retract into the mediastinum. This tube is brought out of the neck incision and is to provide for any mucus or other discharge which may escape when the occluding ligature absorbs. The upper end must be separated sufficiently to allow it to be brought to the skin surface without tension or even to lie well outside the wound, or to be placed in a subcutaneous tunnel conducting it towards or below the clavicle.

If the open lumen of the divided œsophagus is attached to the skin margins, there is risk of infection and, as a consequence, the sutures may give way when the edge of the œsophagus retracts. Should this happen, the cellular tissue of the neck and mediastinum is almost certain to become infected, with fatal consequences. This has actually occurred on three occasions in our experience.

In all operations where the œsophagus has to be brought to the surface, it is essential that it should be redundant and lie loosely on the skin surface. In about three days the cellular tissue round about it will be safely shut off. The redundant portion may then be cut away with the diathermy knife, the division being made at least half an inch beyond the skin surface to allow for retraction. In operations for malignant disease, if a considerable length of healthy œsophagus above the growth can be brought out of the cervical wound, the growth may be cut away and two or three inches of the œsophagus imbedded in a subcuticular tunnel. In these circumstances, the end is brought to the skin margin some distance away from the point where it reaches the surface of the neck.

If the œsophagus between the stricture and the point of ligature is much dilated or infected, pus may collect and subsequently escape into the cellular tissue or give rise to acute mediastinitis by direct extension through the œsophageal wall. For these reasons it would be better either to attach the lower divided end of the œsophagus to the skin or, if that is impossible, to tie a tube into the lumen and to bring it out of the lower end of the incision in the neck.

If a lateral fistula is to be made, the exposure must be the same as already described for œsophagotomy (p. 1484). Stay sutures are placed in the œsophagus below the level of the cricoid and the tube is incised.

As there is a risk of contraction, the opening should be an inch long and the edges should be carefully sutured to the margins of the centre of the skin incision.

With either method provision must be made for collecting the saliva which will escape from the fistula. In the first few days this can be done by tying a rubber tube into the open end of the divided œsophagus or by placing a de Pezzer catheter into an œsophagotomy. Great care must be taken to see that this tube does not fit tightly, as in such circumstances the pressure might lead to necrosis of the œsophageal wall with, in turn, retraction from the skin margin and infection of the mediastinum. A suction apparatus may be usefully employed.

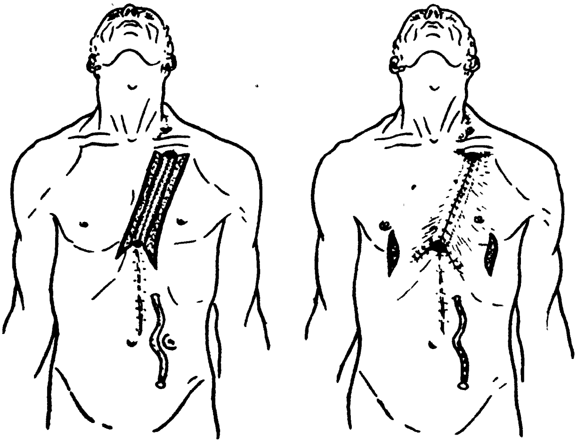

Fig. 707.—Œsophagoplasty.

A. The flaps have been dissected up, rolled over and sutured together to form the skin tube. B. The latter has been covered by undercutting the skin margins, and suturing the edges in front of the dermal tube. To facilitate approximation, lateral tension incisions have been made at either side of the suture line near the costal margin.

If this stage has been successfully accomplished, the œsophagus becomes securely adherent to the surrounding parts. Any excess beyond the skin margin retracts or shrivels and the final result is an opening in the middle of a depression into which the end of the little finger can easily be introduced. The next stage must not be undertaken until the above condition has become established and there is no sign of contraction. Probably four to six weeks is a suitable interval.

Second stage : the formation of the ante-thoracic skin tube.—This is intended to extend on the left side from just below the site of the cervical fistula down to the costal margin. Its direction will usually be slightly oblique, as indicated in Fig. 707. Incisions are made 2½ inches apart and the edges are dissected up towards the centre of the isolated skin area until they can be rolled over and approximated without tension. This should be excentric, so that the anterior closing suture will be towards one side of the new tube. To attain this object the skin from the inner side is dissected up for half an inch and that from the outer side for one inch. This will leave an attachment to the chest wall, near the anterior perforating branches of the intercostals, of not less than an inch broad, which will ensure the blood supply of the large piece of skin required to make the tube. The suturing may be done over a rubber tube about the size of a 14 catheter but this should be removed on completion to diminish all risk of interference with the blood supply. The edges of the skin are first united at a few points as guides. It has been usual to employ fine black silk for these sutures, but chromicized catgut size 6/0 does equally well and does not work out nor produce minute fistulæ, as the silk may do. The sutures are so applied that the knots are inside the skin tube.

The edges between the guides can be united by continuous sutures until the tube is complete from end to end. If the suture line has not been completely turned in, a few additional stitches may be placed here and there in Lembert fashion.

The next step is to cover this tube by skin from the surface of the chest, and this may present difficulty, especially in spare males. As a rule the adjoining skin will have to be freely under-cut, and even so there may be considerable tension. Special lateral tension incisions, as shown in Fig. 707, will help to overcome this difficulty.

The edges of this covering skin are approximated by interrupted sutures, much care being taken to see that the edges are everted. Stitches of silkworm gut should be used at intervals of about an inch. If there is no great tension, finer silkworm or horsehair may be used for the intervening portions. In order to avoid the risk of interference with the blood supply from pressure, only a light dressing should be applied. In hairy male subjects the growth of hairs into the tube might be expected to be troublesome, but it has not proved so. A considerable growth of hair may occur inside the skin tube before the next stage is reached and again before the concluding stage. Such hair can be pulled out with long forceps passed into either end of the tube. As soon as the new œsophagus begins to function the hairs are probably shed and carried along with the food, thus safely passing through the alimentary canal.

Third stage : the construction of the lower jejunal portion of the new gullet.—This should not be contemplated until the edges of the skin tube are securely united and the tension incisions are healed. The ordinary preparation for an abdominal operation will be necessary.

The abdomen is opened in the middle line by an incision extending from high up on the left of the ensiform to the umbilicus. The upper jejunum is found, and a loop of sufficient length isolated, to extend without tension from the end of the skin tube to the stomach. The piece of intestine selected must be opposite one of the primary arterial arcades, and great care must be taken to see that its blood supply is adequate. This must be determined by actual observation of pulsation in the vessels, bleeding from the cut margins, and preservation of normal colour. The length of the loop will depend on whether the operator decides to join it to the anterior or the posterior surface of the stomach. It is assumed, rather than proved, that there is less risk of regurgitation after union with the posterior surface. If the union is to be to the anterior surface, probably a loop about six inches long will suffice, but it will require one of nine to twelve inches to reach the posterior surface. It is important, if the latter route is adopted, that there should be no sagging of the loop. When a suitable portion of bowel has been selected it is divided at either end and the continuity of the parent bowel is restored by end-to-end or other type of anastomosis (Fig. 708).

The isolated loop is then placed so that the normal peristaltic waves will pass from new œsophagus to stomach, and not in the reverse direction. The lower end of the loop is united to the posterior surface of the stomach by end-to-side union. The stomach is exposed by tearing through the gastro-colic omentum, and the anastomosis is made about the middle of the posterior surface. To reach the front of the stomach the isolated piece of intestine must be brought up through the gastro-colic omentum and not around the transverse colon.

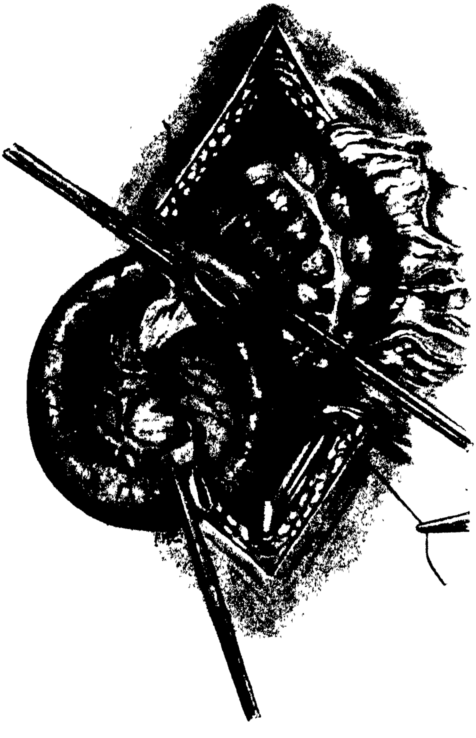

Fig. 708.—Œsophagoplasty. Loop of jejunum isolated and in process of suture to

The abdomen is now protected by swabs or partially closed, and the upper end of the isolated loop is brought into apposition with the lower end of the skin tube. To do this it is necessary to turn back a flap of skin and sheath from the left rectus muscle so that the intestine can be laid in contact with the end of the skin tube without tension. The lower extremity of the skin tube must be isolated from its covering and defined all round, so that it is free for anastomosis to the intestine (Figs. 709 and 710).

The actual union is made on the same principle as an end-to-end intestinal anastomosis. In order to secure good apposition with inversion of the edges into the lumen, it is wise to commence by uniting the posterior part with two or three mattress sutures. (Fig. 710.) These replace the posterior Lembert sutures of an ordinary intestinal anastomosis. The continuous suture is then inserted, each bite being taken by passing the needle from within outwards, thus turning the edges into the lumen. The skin tube will be found too rigid to allow easy inversion in Lembert suture fashion but here and there an interrupted supporting suture can be applied after this principle. Care must be taken not to narrow the lumen at the anastomosis. In some cases stricture has subsequently developed. The abdominal wall must now be closed, leaving just sufficient space for the easy emergence of the small intestine. It is a good plan to anchor the bowel to the parietes by a few points of suture where it transverses the abdominal incision. This serves the double purpose of preventing prolapse of abdominal contents and of providing against harmful drag on the anastomosis. The flap of skin and rectus sheath which was turned down is placed over the anastomosis, taking great care to evert the edges, as fistulæ are apt to develop at the point where the external skin suture and the jejuno-dermato-anastomosis superimpose.

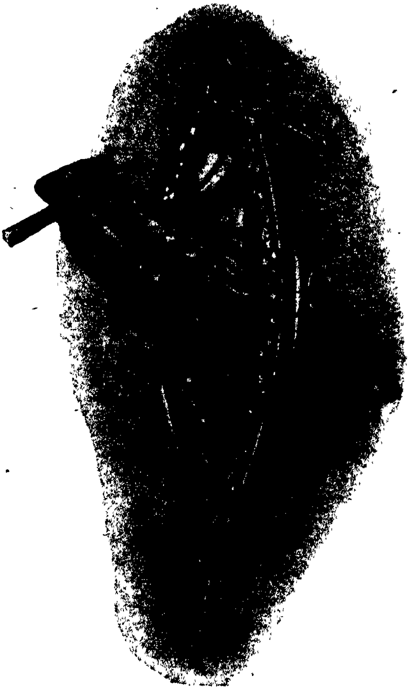

Fig. 709.—Œsophagoplasty. The loop of isolated intestine prepared for approximation to the lower end of the skin tube.

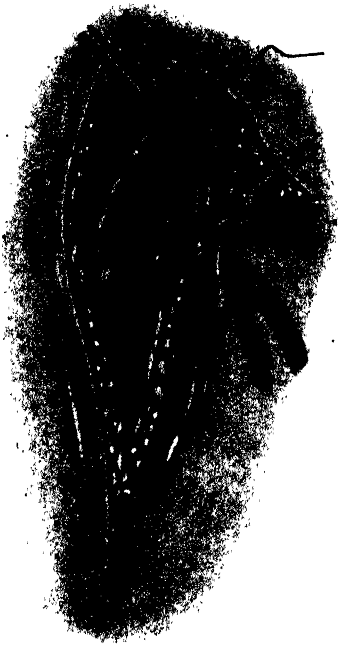

Fig. 710.—Œsophagoplasty. The jejunal portion of the œsophagus being united by suture to the lower end of the skin tube.

Recovery from this stage is like any other laparotomy, but the patient may be expected to be more upset than from any other part of the multiple operations. It will probably be three or four weeks before the union and the laparotomy wound are sufficiently soundly healed to permit the final stage.

If the Janeway or Beck-Jianu gastrostomy has been made previously, then this third stage is replaced by an anastomosis of the lower end of the skin tube to the upper end of the stomach tube representing the gastrostomy opening. In these circumstances, the lower end of the skin tube will have been carried as near the other opening as possible. If the two are thus closely approximated, it will only be necessary to expose the gastric tube by reflecting the skin from its margin and uniting it to the inner skin tube in the way described. Great care must be taken to cover the anastomosis by careful approximation of the skin, the sutured edges being everted. Should a fistula form at the dermato-jejunal or dermato-gastric union, its repair ought to be successfully carried out before the fourth stage is attempted.

Fourth stage : the union of the upper end of the ante-thoracic skin tube to the cervical fistula.—The skin of the chest wall forms the posterior surface of the new gullet, and to bridge the gap between cervical fistula and skin tube it is necessary to provide lateral and anterior walls by fashioning skin flaps and carefully suturing them in position. As in the construction of the skin tube, the upper and lower edges must, of course, be carefully sutured to the freshened edges of the cervical fistula and upper orifice of the skin tube respectively. The raw surface presented must then be covered by skin from either side. To do this it may be necessary to make lateral tension incisions. This union must be made with particular care because it will have to subserve the function of swallowing from the moment of completion. But it is wise not to put too great a burden on the anastomosis, and the patient should be told to expectorate saliva as far as possible and not to attempt to swallow food until the union has had a chance to become sound—probably in two weeks' time.

Difficulties and complications.—It may be very difficult to get the skin to cover the new tube. Tension incisions and under-cutting will give great help, but it may be necessary to resort to skin grafting. It is best to get the skin tube covered even at the expense of large lateral incisions, for even if the latter are slow in healing they can be treated by skin grafting at a later stage.

Of the more serious immediate complications, *necrosis* of some parts of the skin tube or of the skin used to cover it, and subsequent *sepsis* are most to be feared. Both are more likely to depend on deficient blood supply rather than on direct infection. They must be treated on general lines. Though, of course, deaths may result it is interesting to note that necrosis of considerable parts of the new œsophagus has not always precluded subsequent successful repair.

There is no unusual risk of *chest complications* though they have added their quota to the fatal results.

In nearly all the recorded cases, *fistulæ* have formed at one or more points in the new tube. They are most usual at the junction of skin tube and intestine, but may occur at the upper union, or in the intervening portion. Either anastomosis may completely give way, but small holes admitting the end of a pencil or even the tip of a finger are more usual. When very small, these fistulæ may heal spontaneously as the result of careful dressing, with local suction and improvement in the general health, but they usually have to be repaired by suture, and sometimes many attempts have to be made before success is attained. The great principle is to recognize the necessity for separation of the surface skin from the skin tube and the intestine so that these parts may be sutured together independently of the overlying skin. An incision must be made closely surrounding the fistula, and the skin edges dissected back for about one-third of an inch all round. The edges of the opening in the new tube may have to be trimmed a little before being closed by a series of interrupted sutures or a continuous suture passed in such a way that the edges are turned towards the lumen. The covering skin is then carefully sutured, equal care being taken that the edges are everted. It is a great help if, after the repair of the fistula between the skin tube and intestine, a separate flap of parietal skin can be swung over the area like a lid.

Of late complications, *stricture* and *ulceration* in the new tube have been the most troublesome, though neither are common. Stenosis has usually occurred at the junction of the cervical œsophagus with the skin tube. Though treatment by dilatation with bougies will naturally first be tried, such stenosis seems to lend itself to plastic interference in view of its accessible position. Ulceration has been followed by hæmorrhage, perforation and fistula. Dietetic correction, alkalis between meals, olive oil after food and mechanical emptying of the œsophagus by external manipulation may prove both prophylactic and curative measures.

A certain amount of *regurgitation* has occurred even in the most successful cases. For this symptom patients have found it wise to take warm food and not to eat within two or three hours of going to bed. Sleeping in a reclining position, rather than quite flat, for the first few hours after retiring, has also been helpful. The exposed position of the new gullet must render it liable to injury from external violence, and those whose occupation renders them vulnerable would be wise to protect the part by some sort of shield made of strong leather or similar resistant substance.

Results.—The published results do not always give a correct indication of the difficulties and dangers of an operation of this sort. Making due allowances it is probably correct to assume that the mortality is not less than 35 per cent. and that probably not more than 50 per cent. of the cases in which the operation has been begun have been carried to a successful conclusion. But with careful selection of cases, multiple stage operations and intelligent and careful technique, there is no reason why the results should not be very much better in the future. (Fig. 711.)

Modifications of the technique are being introduced from time to time and to keep abreast of these developments it is necessary to study the recent literature, which is becoming voluminous.

OPERATIONS FOR SIMPLE TUMOURS

Papillomata and fibromata may be pedunculated and project into the lumen of the œsophagus, and myomata or lipomata may arise in the substance of the wall and cause more or less obstruction. Congenital cysts have also been found in the œsophageal wall or involving the wall from outside.

The papillomata, and possibly some of the other tumours invading the œsophageal lumen, may be removed endoscopically, with or without the aid of diathermy, though it must be observed that the latter method has proved dangerous.

The larger simple tumours causing obstruction must either be palliated, by partial endoscopic removal or by gastrostomy, or they must be removed by enucleation after exposure by the posterior mediastinal or trans-thoracic route.

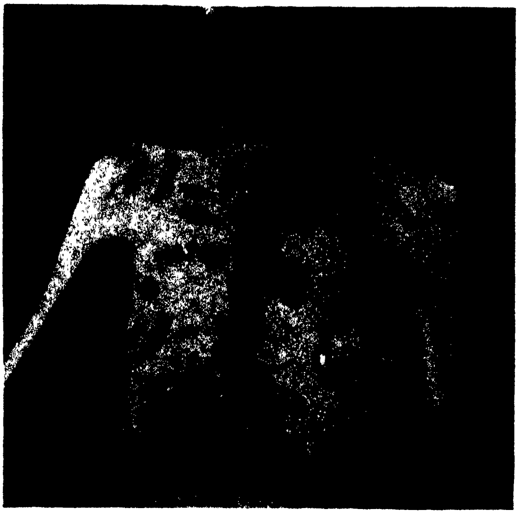

Fig. 711.—Œsophagoplasty completed. Patient with all wounds healed and function established.

The photograph was taken on the 206th day after excision of the thoracic œsophagus for malignant disease.

MEASURES FOR THE RELIEF OF CARCINOMA

When malignant disease attacks the œsophagus, it nearly always takes the form of carcinoma ; the pathological features of its invasion and spread are not in any way peculiar to the site, but follow the usual course of carcinoma in other parts of the alimentary canal. While it is probably true that about one-third of the cases display early dissemination to the lymphatic nodes, the liver and more distant parts, in the remaining two-thirds slow, steady invasion of the surrounding structures with death from inanition, sepsis or lung complications are the main features. Unfortunately, when patients present themselves for surgical advice, the growth has usually been in existence for a comparatively long time. Even when dysphagia first declares itself, the growth has often already spread beyond the walls of the œsophagus. In the whole of its course the œsophagus is in close contact with important structures that may be involved by direct spread, but it is often difficult to determine clinically the degree of extension present. There is the further difficulty that the œsophagus, throughout the greater part of its course, is anatomically secluded and difficult of access.

Short of such gross evidence as the presence of enlarged glands in the neck, demonstrable secondary deposits in the liver or gross involvement of the lung or pleura, it is often difficult to estimate accurately the local spread of the growth. Even when the history is short and the local condition appears favourable, as demonstrated by X-ray and œsophagoscopic examination, the growth, on exploration, may be found to have spread to the surrounding parts to such an extent that it cannot be excised. This has been the experience of all pioneer workers in this field. Fortunately the converse is equally true, and some growths are found to be strictly localized to the œsophageal wall and quite capable of removal.

Although X-ray therapy and radium are both valuable as palliative measures, there is no proof that they are curative, whereas a few cases treated by operation have remained free from recurrence for several years. In these circumstances, it is perfectly justifiable to consider radical removal, and to undertake it if the surgeon has had adequate training.

METHODS OF TREATMENT

Curative.—(1) Removal by endoscopic methods. (2) Removal by the operation of œsophagectomy: (*a*) In the cervical region; (*b*) At the lower end of the œsophagus; (*c*) In the thoracic region by trans-pleural, collo-abdominal, or "pull-through," or posterior mediastinal routes.

Palliative.—(1) Repeated dilatation: (*a*) Under direct vision; (*b*) By thread-guided method. (2) Intubation. (3) Diathermic coagulation. (4) Irradiation: (*a*) Superficial application of radium; (*b*) Interstitial irradiation; (*c*) Teleradiation and deep therapy. (5) Gastrostomy.

Removal by endoscopic methods.—On one or two occasions a malignant growth has been detected through the œsophagoscope at such an early stage that it could there and then be removed by nibbling forceps or by diathermic excision. In practice, the growth is almost invariably so far advanced when the question of treatment arises that radical measures, to have the least chance of success, must involve the removal of a complete section of the œsophagus.

Œsophagectomy.—All the methods of œsophagectomy must be governed by the knowledge that it is never possible to make an end-to-end anastomosis if the malignant growth has been excised sufficiently widely. Because of the tendency of the growths to spread up and down beneath the mucous membrane it is essential to remove a considerable length of œsophagus above and below the obvious growth, and this further complicates the problem. The selection of cases always merits serious consideration. In Great Britain, the disease most commonly attacks male subjects over the age of 60. Many of the patients are the victims of cardio-vascular disease or of emphysema, often with chronic pulmonary infection; furthermore, the renal function is frequently poor. Such subjects are bad risks for any type of surgical interference, much more the very serious type of operation under consideration. None the less, direct surgical attack may be considered when the patients are young for their years and well preserved, when there is no evidence of distant dissemination and when the improvement after gastrostomy is so great as to suggest that most of the symptoms have been due to malnutrition following obstruction.

Before any attempt at radical operation an endoscopic examination should be made. This will not only confirm the diagnosis, but will give some indication of the extent and type of the neoplasm. The position of the growth and the degree of mobility of the œsophagus may also give some information on the degree of fixation to surrounding structures, particularly in neoplasms affecting the middle segment, where the trachea and left bronchus are in direct relationship. Visual evidence of invasion of the bronchial tree may be provided by bronchoscopic examination, which should never be omitted in growths related to the trachea or bronchi. In some few cases the growth may actually have broken through into the air tract without giving rise to symptoms.

When excision is contemplated, an upper exploratory laparotomy to exclude secondary deposits in the liver and infiltrated nodes along the lesser curvature should be made as a first stage and should be combined with gastrostomy. If the condition of the patient permits, this may be of the Janeway or Beck-Jianu type, so that the gastric fistula may later be used to form a new extra-thoracic œsophagus, or the more ready union to a cervical fistula by rubber tube. If there are no secondary deposits and the patient rapidly improves as a result of the gastrostomy, the exploration of the œsophagus may be contemplated three or four weeks later. Preparatory measures, such as the hygiene of the mouth, the care of the lungs and heart and blood transfusion, must be considered.

The technique of œsophagectomy must be correlated with the anatomical position of the growth. Three regions have to be regarded as separate problems: (*a*) the cervical, (*b*) the thoracic and (*c*) the lower end.

In the cervical region growths may be approached by an incision such as is employed for œsophagotomy. If the larynx and trachea are not involved, the œsophagus, with the growth, may be readily isolated from its bed by blunt dissection with the finger. If the growth is limited in longitudinal extent, the pharynx above and the œsophagus below may be divided and the involved segment removed. In these circumstances, the gap between the ends may be bridged by a new tube constructed of a skin flap or flaps cut from the neck. The operation is best carried out in two stages. At the first stage the incision for exposure is made in the form of a large flap (Trotter) ; the affected portion of œsophagus is isolated and excised. The skin flap is then laid in the bed from which the œsophagus has been removed, in such a way as to form a gutter. The second stage consists in the transformation of the gutter into a tube, to replace the œsophagus.* These points can best be understood by reference to Fig. 712. The approach is usually made from the left side unless there is some special reason to use the right, such as extension of the growth beyond the wall of the œsophagus or, for instance, involvement of the thyroid.

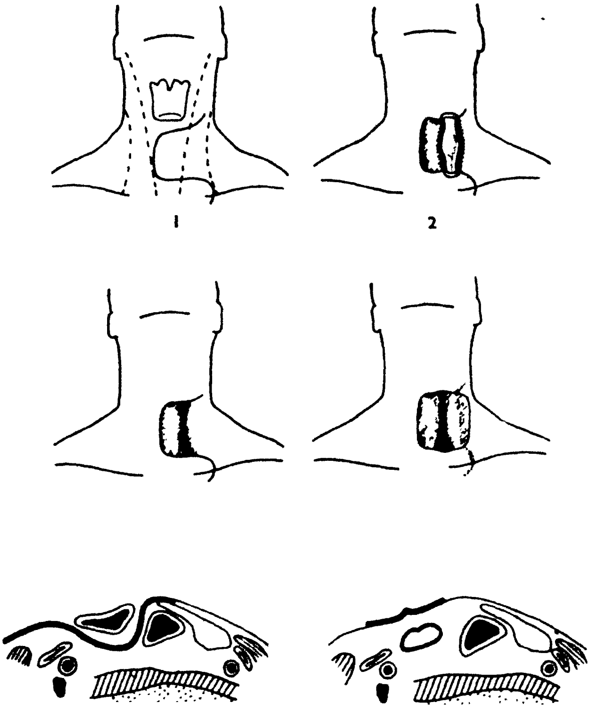

Fig. 712.—Cervical œsophagectomy with reconstruction.

1, The skin flap outlined ; 2, the segment of œsophagus containing the growth completely separated from its surroundings and the skin flap tucked beneath it and fixed by suture ; 3, four days later the affected segment is cut away. The ends of the œsophagus now open into the trough of skin formed by the flap ; 4, some three or four weeks later the flaps shown outlined are cut on either side of the trough and turned in over it, where they are sutured, converting the trough into a tube replacing the excised portion of œsophagus ; 5, diagram of transverse section of neck showing flap laid under isolated portion of œsophagus. The right lobe of the thyroid has been removed ; 6, the œsophageal segment has been excised and the trough wrapped round and converted into a tube over which the skin has been sutured. (Modified from Pilcher, *Lancet*, 1937.)

The flap should be carefully planned and its extremity must extend beyond the middle line. It should be taken from the space between the upper border of the larynx and a point just above the sternum, and its base must be broader than its apex. It includes the skin and subcutaneous tissue. Great care must be taken not to injure vessels entering the base of the flap on which its nourishment may depend. After the flap has been turned back it should be kept warm with moist gauze. The exposure is then made as described in œsophagotomy. In cases really suitable for excision the growth lies loosely in its bed of cellular tissue, from which it can readily be separated by the finger. Extension to the thyroid or invasion of neighbouring lymph nodes does not necessarily mean that excision is impracticable, but separation and removal must then be made under the guidance of the eye, and cutting instruments will be required. When the growth is fixed on the opposite side to that approached, the operation should not be hastily abandoned, but the area of fixation should be exposed by dissection, an additional incision being made if necessary. The condition may turn out to be more favourable than might have been expected. When the parts outside the œsophagus are not invaded, the recurrent laryngeal nerve usually escapes but if it is actually involved by growth it will have to be divided and a portion excised.

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* The operation may often be modified by excising the growth at the first sitting, but the completion of the dermal tube should always be left to a second stage.

When the œsophagus with the growth has been mobilised and there is a free portion above and below, the parts are ready for excision; the pharynx should be cut across first, but this should be done piecemeal, each bit of cut edge being caught by forceps or by a stitch so that it is accessible for suture to the skin flap when the latter is placed in position. When the pharynx has been divided, the œsophagus with the growth can be held conveniently and a little traction applied so that the œsophagus below the growth can be seen and divided strictly transversely. But this should also be done piecemeal, and the edges caught at several points to guard against retraction of the lower end into the mediastinum.

The next step is to adjust the skin flap to occupy the gap between the two ends and to make a gutter as shown in Fig. 712 (3). When the flap is in position the lower cut edge of the pharynx is sutured to the upper border of the skin flap. This is best done by interrupted sutures of fine chromic catgut passed in such a way that the edges of the structures are turned slightly inwards, i.e. towards what will be the interior of the new tube. Similarly, the posterior edge of the cut œsophagus is stitched to the lower border of the skin flap. It is most important that there should be no tension and, in any event, one or two of the sutures should be of the mattress variety to secure a very good hold. The other edge of the œsophagus should be secured to the skin margin to prevent retraction and to protect the cellular tissue. The remainder of the cut end of the pharynx should be anchored in a similar way. The gutter and the space between the ends of the pharynx and œsophagus respectively should be covered by oiled silk on to which gauze can be packed.

When gastrostomy has not been carried out, a feeding tube with a lateral hole is inserted into the œsophagus. This may be passed through the mouth or nose, or directly into the open end of the œsophagus from the neck wound. The latter is probably the better plan. Gastrostomy will do away with the difficulties of feeding but nevertheless there will be continuous soakage of the neck dressings by saliva. As soon as the patient can manage to do so, he should be encouraged to expectorate frequently, but in the early stages the gauze, which is only lightly packed, should be changed frequently and free use should be made of the aspirator. The constant attention of a special nurse properly trained to deal with such cases is almost essential if they are to be carried to a successful conclusion.

If all goes well, the area will be gradually sealed off by granulations, later replaced by fibrous tissue, so that in two or three weeks the pharynx on the one hand and the œsophagus on the other will be incorporated with the upper and lower ends of the gutter. Primary union often occurs, but there should be no haste in attempting to complete the formation of the dermal tube.

The final stage consists in completing the tube by turning in skin flaps to make the anterior wall, and this is done in much the same way as for the dermal tube in the formation of the ante-thoracic œsophagus (see p. 1502). Incisions are made in the lateral, superior and inferior boundaries of the gutter, and the skin is undercut, so that the margins can be folded in and sutured together in a tubular manner. The outer raw surface is covered by undercutting the skin at the side of the neck so that it can be sutured over the newly-made dermal tube. The main difficulty is to secure enough skin for this purpose and skin-grafting may be required. After about three weeks, in satisfactory cases, union will be firm enough to allow natural swallowing.

The constricting type of carcinoma may occur in the cervical œsophagus and may be present as a small, very well-localized lesion. In these circumstances it may be completely separated from its connections and left *in situ* in front of the skin flap which is passed behind it as shown in Fig. 712. The object of this is to allow the cellular tissue to become shut off and the œsophagus fixed at the ends before the affected portion is cut away. The actual excision may be delayed for about four days and should be made with the electro-cautery. In spite of the time allowed for connections to form, it will be safer to put in a few sutures between the cut ends of the œsophagus and the skin flap.

When the growth is low down in the cervical region or extends into the upper mediastinum it is usually supposed that the operation must be abandoned, but this is not always necessary. In these circumstances the growth may often be removed, as the œsophagus in this situation readily lends itself to separation from the cellular tissue bed in which it lies. Preliminary gastrostomy is essential. Separation may be carried as far as the arch of the aorta, but to carry it so low, excision of the inner end of the clavicle or even of the upper corner of the manubrium sterni is a great help. The separation is entirely carried out by the finger. When a point well below the growth has been reached, the œsophagus must be occluded by ligature. It is first crushed with a right-angled clamp and then very firmly ligatured with No. 5 chromic catgut. The application of this ligature is a difficult step, and it may prove easier to transfix the œsophagus with a ligature on a needle. After being securely tied, the œsophagus is divided with the cautery, knife or scissors. In any case the divided end is smeared with Bipp, which is also rubbed into the surrounding cellular tissue. The upper end with the growth is brought out of the incision and fixed well outside the wound and is managed as in complete œsophagectomy. In these circumstances restoration *in situ* is not feasible, but continuity may subsequently be established by the formation of an antethoracic œsophagus.

When there is limited extension to the thyroid or the trachea, some portion of either may be removed with the growth. If the trachea is involved, tracheotomy will be required. More extensive involvement of these structures can only be dealt with by removing a lobe of the gland or section of the trachea in one piece with the œsophageal growth. The method then employed is associated with the name of Gluck. This is a very mutilating operation and, though the gap between the pharynx and œsophagus may sometimes be bridged by a series of plastic interventions, the trachea must be left permanently open just above the sternal notch. The mortality is naturally high, and there are very few British patients willing to submit to so much risk when the permanent disability is so embarrassing. Only those with an intense desire to live and a corresponding determination should be submitted to the ordeal. Fortunately the resources of radium and deep X-ray therapy have provided some alternative.

Combined laryngectomy and œsophagectomy (Gluck's operation).— The main steps of this operation are as follows :—1. A midline incision is made from just above the hyoid to the episternal notch. 2. Transverse incisions at either extremity of the vertical incision extend from the anterior border of one sterno-mastoid to the other. 3. The quadrilateral flaps so made are dissected back to the full extent of their demarcation. 4. The trachea is exposed in the lowest part of the neck and is cut across, the open end being fixed in the lower extremity of the vertical incision so that it faces directly forwards. The administration of the anæsthetic is now continued through the open end of the trachea. 5. The larynx and remainder of the trachea, the lower part of the pharynx and the cervical œsophagus are isolated and removed *en bloc*. The extent of this ablation is determined by the spread of the disease, remembering that if a margin of healthy tissue cannot be assured beyond the growth the operation is not justified. 6. If a portion of the posterior wall of the pharynx and œsophagus can be left *in situ*, it should be sutured to the edge of the vertical incision so as to form a muco-cutaneous gutter. 7. If the whole segment of pharynx and œsophagus have to be removed, no attempt is made to close the pharynx by suture, and the space will have to be packed with gauze. The upper end of the divided œsophagus is attached to the surface lateral to the open trachea and as far removed from it as practicable. 8. When the pharynx and œsophagus have been completely removed, the skin flaps are sutured together over the raw area. 9. At a later stage it may be possible to construct a dermal tube connecting pharynx to œsophagus. Otherwise the patient must be fed through a tube passed into the open mouth of the œsophagus on a funnelled tube connecting pharynx and gullet.

The lower end of the œsophagus.—When the growth is in the extreme lower extremity of the œsophagus, it may be limited to that part of the tube which lies in the abdomen. In these circumstances it may be possible by an abdominal exposure to mobilize and excise the growth and to make a direct anastomosis between the divided end of the œsophagus and the stomach; there are cases on record (Gobrandt) in which this has been carried out with success. But even when the growth is strictly limited and this local excision can be made, the division of the œsophagus cuts off the main blood supply to its lower end through the left coronary artery, and the poor nutrition may not be enough to vascularise the suture line, and the anastomosis is apt to give way or to leak. But there are very few cases in which the growth is sufficiently localized to make this sort of operation possible and, in the majority, the growth demands the removal of so much of the œsophagus that a direct anastomosis to the stomach cannot be made within the abdomen.

In these circumstances, operations have been devised in which, by a combined abdomino-thoracic approach or a transthoracic approach with incision of the diaphragm, the stomach is displaced into the thorax so that union by suture between the divided œsophagus and the fundus can be effected. These operations, though technically feasible, have been followed by a high mortality. Recent modifications, such as burying the union in the stomach fundus, hold out greater promise (Garlock, Brock, Sampson). Other methods have had some success. By a combined operation, abdominal and transthoracic, Muir excised a growth and brought the divided end of the œsophagus out on to the back through an adjoining intercostal space. Ogilvie, after removing a growth, restored the continuity of the œsophagus *in situ* with a tube made from the greater curvature of the stomach.

When the lower part of the œsophagus has to be excised, it is probably safer to remove the remainder of the thoracic portion and to bring the upper end out on to the neck. These methods are technically feasible, and have many times been carried to completion. As yet, however, recoveries from the operation are few.

For growths in the thoracic part of the œsophagus there are three possible routes of approach: the transthoracic (Torek), the collo-abdominal or pull-through method (Grey Turner, Denk) and the posterior-mediastinal (Lilienthal).

THE TRANS-THORACIC ROUTE

This was the method adopted by Torek in dealing with his first notable success. Many surgeons the world over have conscientiously worked at this method and have practised it on many occasions, but it is only during the last year or two that several successful cases have been reported. (King of Melbourne, Garlock of New York, Franklin of London, Allison of Leeds, *et al.*)

The method has the advantage that the major part of the operation can be carried out under the guidance of the eye but there is the great disadvantage that the pleural cavity is exposed to infection and that the lung must be collapsed and is liable to trauma from handling and to other changes with septic manifestations which have often proved fatal. But the method has now been frequently employed and one of us (G.G.T.) has removed the whole thoracic œsophagus in this way on many occasions. In the earlier operations, the *left* pleural approach was always employed, but anatomical observation and consideration* suggested that the *right* pleural cavity commanded access to a greater extent of the œsophagus and was, therefore, probably more suitable. Having tried both routes, we advise that, for growths situated in the lower third of the œsophagus, the left approach is the more suitable, whereas for growths in the upper two-thirds the right gives a better exposure.

Technique.—The general preparation is the same as for any interference with the œsophagus and for thoracotomy. Preliminary gastrostomy is always required. The patient must be placed comfortably on the side, right or left, depending on the pleural cavity to be approached, and the uppermost arm is elevated and supported. General anæsthesia by intratracheal tube with gas-oxygen-ether has proved satisfactory, but it is wise to block the intercostal nerves, not only of the space to be incised, but also of the two spaces above and below. A skin incision is made along the length of the 7th interspace from its anterior end right backwards and then upwards parallel with the vertebral border of the scapula as high as the 3rd rib. The muscles are incised down to the intercostal space, great care being taken to catch and ligature all bleeding points. This part of the operation may be carried out with the diathermy needle, which may perhaps save a little time and blood loss. The edges of the incision having been retracted, and the whole intercostal space exposed, the latter is opened at its anterior end. The incision of the pleura should be small at first and only gradually increased, using scissors, until it extends along the whole length of the space. After the pleura is freely opened, a moment or two should be allowed for the patient to settle. When breathing is quiet, the rib spreader is inserted and the ribs are slowly and steadily separated until the whole hand can easily be introduced into the chest. The lung can then be gently displaced forwards and upwards exposing the œsophagus by the side of the vertebral column and in close proximity to the aorta (Fig. 713). The extent to which the ribs can be separated varies very much in different subjects. When the spread is inadequate, the two ribs immediately above and below the intercostal space should be divided just in front of the articular processes. This is to be done with great care for there is some risk of hæmorrhage from torn vessels. Instead of relying on spreading, some operators prefer to gain room by removing one or two ribs.

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* O'Shaughnessy and Raven, *Brit. Journ. Surg.*, 1934, xxii, 365.

When the site of the growth has been verified, very careful examination must be made to determine its relation to the surrounding parts. There may be obvious extension to the pleura, the lung, or the pericardium ; if so, the operator must use his judgment as to whether or not the involved area can be safely removed with the growth. If there is no evidence of such implication, it is a good plan to distend the cellular tissue around the œsophagus by injecting two or three ounces of local anæsthetic (0.5 per cent. procaine). This not only makes it easier to manipulate in the cellular tissue but helps to thrust the opposite pleura away. The mediastinal pleura covering the œsophagus is incised, and a finger, introduced into the cellular tissue, is gently insinuated up by the side of the growth. It is usually easy to carry the finger up beyond the growth behind the œsophagus and often on the inner side, but many growths seem to become attached anteriorly to the structures at the root of the lung. An attempt must be made to separate in this situation and as the finger is insinuated it must be used to push the structures gently aside rather than to force them apart. Sometimes the growth is very readily isolated in this way and the finger can be passed around it with ease. If the œsophagus cannot be separated easily from its surroundings by gentle manipulation, it is unwise to use force, because it is so easy to tear into the growth, in which case infection is almost sure to follow, with fatal result. In the happy event of the separation being easy, the œsophagus must then be freed to a point at least 2 inches

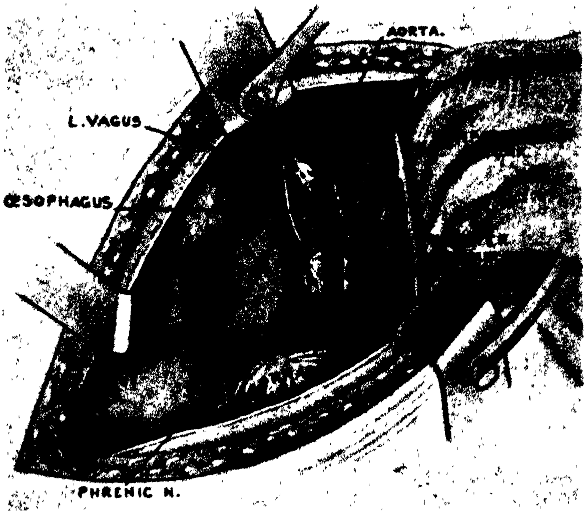

Fig. 713.—Transthoracic exposure of the œsophagus from the left side.

below the growth. It is convenient to pass a tape or a pair of ring forceps around the œsophagus so that this structure can be drawn somewhat into the pleural cavity where it is more accessible. When the point of division below the level of the growth has been decided, the muscular wall of the œsophagus is gently incised with a knife until the submucous tissue is reached. An encircling ligature is then tightly applied so as to occlude the mucous membrane. The remainder of the œsophagus may now be cut across with the diathermy knife or the scissors. The lower end is smeared with Bipp and the ligature divided, when the mucous membrane will retract into the muscular tissue, or it may be tucked in without difficulty. One or two sutures, which have already been placed, are then used to draw the muscle coats together, burying the ligatured mucous membrane. When the division has to be made very near the diaphragm there is a risk of the lower end retracting through the hiatus. To avoid unfortunate consequences from this accident the ligature of the mucous membrane must be very secure. There are some considerable vessels in this situation and these may require independent ligature. When the growth is very near the diaphragm that muscle can be freely incised in order to draw the cardiac end of the stomach up into the chest so that the viscus may be divided well below the growth and carefully repaired by suture. The upper part of the œsophagus which is to be removed must now be securely held by its ligature, while the cut end is protected by gauze or a rubber cap securely tied over it. To some extent it may then be lifted away from its bed, but separation by the finger in the cellular tissue must be carried out towards the root of the lung and eventually behind it and the arch of the aorta (Fig. 714). On the right side the azygos vein makes a very definite wide arch, which can readily be seen and usually avoided. Where the azygos arch is small or where the growth is adherent at this point or very bulky, the vein may be doubly ligatured

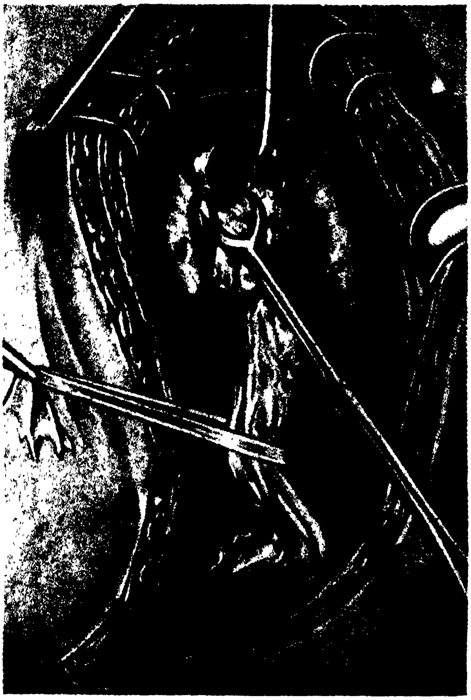

Fig. 714.—Resection of a portion of the thoracic œsophagus for carcinoma

The œsophagus is being freed by blunt dissection from under the aortic arch; several small arteries enter the œsophagus here, and must be isolated and ligatured separately. (Reproduced, by permission, from B. Noland Carter, *Surg. Gyn. and Obst.*, 1940, lxxi, No. 5.)

and divided. It may help the process of separation to incise the mediastinal pleura covering the œsophagus above the level of the arch of the aorta, or the azygos arch as the case may be, so that the finger can be more readily introduced into the cellular tissue in this situation, but this part of the œsophagus is usually better separated from the neck.

When the œsophagus has been mobilized as high up as possible, the bed from which it has been removed is very carefully inspected and all bleeding points are caught and tied or arrested by silver clips. When quite dry it should be rubbed with Bipp or with sulphanilamide powder. The edges of the pleura are drawn together here and there with interrupted sutures of catgut. A rubber tube should be laid in the lower part of the œsophageal bed or at least in the vicinity, and brought through the parietes by an independent incision so that it can be drawn up into the neck. If the surgeon feels sure that the œsophagus is completely separated from its thoracic connections the chest may now be closed, thus completing the thoracotomy part of the operation.

The growth, if very bulky, instead of being drawn up through the superior mediastium into the neck, as in the original Torek method, may be be cut away and removed in the thorax, leaving only the upper end of the œsophagus to be eventrated. If there is any doubt about the complete separation of the gullet, the opening into the pleural cavity is not closed but temporarily packed with large swabs and thoroughly covered with warm moist towels, or the skin may be drawn together over large swabs. The patient is then turned gently and quietly on to the back and the root of the neck exposed with the shoulders elevated and the head turned to the right side.

It is well to give the patient a few minutes' rest before proceeding with the next stage of the operation, and during this interlude to take stock of the general condition. An oblique incision along the anterior border of the sternomastoid can be used for the exposure of the cervical œsophagus as in œsophagotomy, but we have found that better access is obtained by an incision parallel with and just above the clavicle, the sternomastoid being completely divided in this line. The œsophagus is then exposed as in œsophagotomy and must be gently separated from the surrounding parts by blunt dissection with the finger, care being taken to avoid the recurrent laryngeal nerve. As a rule, this nerve is not seen and practically always escapes injury. As soon as the finger can be hooked round the œsophagus it may be replaced by a loop of tape or the ring forceps, while the process of separation is carried on downwards with the finger passed into the upper mediastinum. In fortunate cases the finger will meet the growth and can be swept all round it. As soon as this has been done, or when the cellular plane opened up from below has been reached, gentle upward traction is made and then the isolated œsophagus can usually be drawn easily into the neck. Sometimes it is still firmly fixed in the thorax, despite the fact that it appeared to be completely mobilized from below. In these circumstances, while traction is kept up, the surrounding parts may be gently pushed aside from the neck wound with the finger or a small pledget of gauze held in long forceps. If this does not suffice to release the œsophagus, the patient should be turned over and the thoracic wound exposed so that separation may be completed by working from the chest, or chest and neck together. Once the œsophagus has been completely mobilised, it must be withdrawn from the neck and allowed to hang out of the wound. The next point is to decide the most convenient spot for it to lie over the clavicle. When this has been settled, the sternomastoid is drawn together about the œsophagus, which is attached to the muscle by one or two catgut stitches. The skin incision is then carefully closed around the œsophagus which, at the end of this stage of the operation, will be hanging freely over the front of the chest. Its subsequent disposal has already been discussed (p. 1500).

This stage having been accomplished, a return may have to be made to the thoracic cavity. After removal of the swabs an inspection is made for blood clots, etc., which are removed. The gauze is removed from the œsophageal tunnel and one or two other small vessels in the tunnel may have to be tied or occluded by silver clips. The chest is then closed and the patient is ready for return to bed. The drainage tube is put under a water seal and will probably have to be left *in situ* for about forty-eight hours.

Throughout the whole operation, great gentleness must be observed, there must be no haste, and twice or thrice during its course all manipulations should cease and the patient be allowed to rest for a few minutes. Should the condition demand it, intravenous glucose and saline should be given or a blood transfusion administered during the course of the operation. Fresh instruments and gloves should be used for each stage. The whole proceeding will take 2½ to 3½ hours or even longer.

After-treatment.—Shock is not a marked feature at first, but there may be some delayed hæmorrhage, and in any case blood transfusion is wise in the immediate post-operative period. The patient should be nursed in an oxygen tent; morphia will certainly be required at first. Tension pneumothorax, infection of the pleura and a low form of pneumonia are the great risks. In some cases, a localised empyema has required drainage. Arrangements must be made to collect the saliva from the upper end of the œsophagus, and if that is done the patient may, if so desired, be allowed to drink almost from the first. The after-care is in general that required for thoracotomy.

THE COLLO-ABDOMINAL, OR "PULL-THROUGH" METHOD

This operation was devised during the period when the trans-thoracic route was attended by so many disappointments that most surgeons were almost in despair about the future of radical operations for cancer in this situation. The method has been attended by some success, but it presupposes a growth entirely limited to the œsophageal wall and without fixation of any sort.

Technique.—Briefly, the steps are as follows :—It is assumed that as a *first stage* there has been a preliminary exploration of the abdomen with gastrostomy. In the *second stage* the abdomen is re-opened and the left lobe of the liver is detached from the diaphragm and turned to the right, exposing the abdominal portion of the œsophagus. Several ounces of 0.5 per cent., novocain or procaine solution are injected around its lower end, the needle being passed through the hiatus. The object is to distend the cellular tissue in the hope of displacing the pleura by the bulk of the injection and to make it easier for the finger to travel in the cellular tissue. The peritoneum over the abdominal œsophagus is then incised, and enucleation commenced by the forefinger introduced through the hiatus and worked up as far as possible around the tube. (Figs. 716 and 717.) If the growth is situated lower than the aortic arch it can usually be reached, and in favourable cases surrounded, by the finger. If very long, it may not be possible to reach its upper limit, but as the finger is working around the growth gentle traction may be made on the œsophagus and this may render the growth more accessible. At this stage, or in fact at any stage during the process of mobilisation, one or other pleura may be torn. With a satisfactory intra-tracheal anæsthesia this scarcely affects the patient, and even with ordinary inhalation anæsthesia the disturbance is not necessarily great. When both pleuræ are torn, though the patient does not necessarily succumb, the accident adds new dangers during the post-operative period, and there may be considerable hæmorrhage from the œsophageal tunnel into the pleural cavities. It is essential to ascertain that the lungs are properly expanded and continue so afterwards.

If at any point the growth is so firmly adherent that it cannot be stripped by the finger, the operation should be abandoned. Forcible separation will tear the growth and this accident is invariably followed by acute mediastinitis and death. If the growth can be completely mobilised, the œsophagus may be ligatured and cut across just above the cardia, in anticipation of its complete removal from above. The lower end is tucked into the stomach or it may be dealt with in the same way as when divided in the lower part of the chest. The free cut end of the thoracic œsophagus is carbolised, rubbed with Bipp or sulphanilamide and covered with a piece of gauze which is securely tied over it with a strong silk ligature. The œsophagus with the ligature is pushed gently up into the œsophageal tunnel which is then temporarily packed with gauze to diminish hæmorrhage and to prevent air being sucked into the mediastinum. Great care must be taken in carrying out this step lest an intact pleura is inadvertently torn. The abdominal wound is temporarily drawn together by a couple of strong silk sutures and the whole area covered with sterile towels, while the field of operation is transferred to the neck, the patient being allowed to rest for a short time while intravenous glucose-saline is administered.

The *third stage* is the separation of the œsophagus in the neck, carried out in precisely the same way as described for the trans-thoracic operation. If the growth cannot be completely separated from above and drawn into the neck the mobilization may be completed by re-opening the abdominal incision and working with the fingers of one hand from below and the other from above. When the œsophagus has been delivered into the neck the remainder of the incision is closed around it as has already been described.

At the *fourth stage* the abdominal part of the operation must be completed. The open œsophageal tunnel is closed by suturing the left lobe of the liver over its mouth, or if the lobe does not lend itself to this manœuvre the great omentum may be packed into the orifice and will remain in position without sutures. The abdominal incision is carefully closed, care being taken to re-establish the gastrostomy.

Shock is not necessarily severe after this operation and, in fact, when the pleura is uninjured, the immediate after-progress is easy. The most serious complication is a low form of pulmonary infection, which sooner or later becomes septic and is often fatal.

Posterior Mediastinal Approach

Another method is to approach the œsophagus by the posterior mediastinal route much after the technique described for posterior mediastinal œsophagotomy. This operation has always made an appeal on paper, but in actual practice it is found that the œsophagus lies very deeply from the posterior surface of the body and it is almost impossible to expose it and to complete separation without tearing the pleura. Nevertheless, not only has the malignant œsophagus been excised by this route, but continuity has been restored by a plastic operation, using a large flap of skin. If the œsophagus is dealt with by this route, either a section can be excised and the two ends left *in situ* for subsequent attempts at restoration of continuity by plastic measures, or the lower end may be ligatured and allowed to retract while the upper part may be enucleated and dealt with as in the trans-thoracic route. In the latter case the wound closes by granulation.

At this stage in the development of œsophagectomy for cancer the posterior mediastinal approach is not recommended, but many changes are likely to occur in the evolution of a difficult problem and it may again come to be regarded as a method for occasional selection.

The fate of the vagus nerves in œsophagectomy.—In any operation for removal of some part of the thoracic œsophagus, one or both vagi may be divided or a section may be removed. This does not appear to have had any notable effect on the progress of these cases, but we are aware that its consequences have not been sufficiently investigated by scientific methods.

Restoration of swallowing after œsophagectomy.—After successful removal of the œsophagus the question naturally arises of restoration of the swallowing apparatus. Sometimes the stomach may be mobilized and drawn up into the chest so that the fundus can be united to what may be left of the upper part of the œsophagus. When the whole thoracic œsophagus has been removed, swallowing may be restored by the construction of an antethoracic gullet (p. 1497). When for any reason this plastic restoration is not attempted, the end of the cervical œsophagus and the gastrostomy may be connected by a rubber tube. The adjustment of the tube in order to prevent leakage has been troublesome, but in some cases such an apparatus has proved quite satisfactory.

CHOICE OF METHOD

At the present stage in the development of œsophageal surgery the trans-thoracic approach appears to have the most advantages and offers the best chance of success. For growths situated in the lower third, the approach from the left side is recommended but for those situated above this point the right trans-thoracic exposure offers many advantages.

PALLIATIVE MEASURES

The measures available are: (1) Repeated dilatation; (2) Intubation; (3) Destruction by diathermy; (4) Irradiation by radon; (5) Deep X-ray therapy; (6) Gastrostomy.

If it is possible to maintain the lumen of the œsophagus and thus to allow of more or less normal swallowing, a great boon will have been bestowed on the patient. Not only can sufficient nourishment be administered to maintain strength, but the saliva can be swallowed. Accumulation of secretion in the hypopharynx produces great discomfort and necessitates constant efforts by the patient to remove it, in order to prevent its overflow into the larynx and trachea. Gastrostomy will permit of sufficient nourishment, but it does not overcome the difficulty of disposal of the saliva.

Dilatation.—Simple dilatation of a malignant stricture gives temporary relief. If it can be easily repeated the swallowing act may sometimes be preserved almost until death occurs from dissemination. The blind passage of bougies is especially dangerous in malignant cases, but sometimes a Hurst bougie will slip through a growth with ease and may be used repeatedly.

Dilatation under direct vision, through an œsophagoscope, is readily performed, but its benefits are only temporary. Gum-elastic bougies may be used or, preferably, a dilatable bag on a flexible hollow stem. To get the full advantage of the method, it must be followed by repeated dilatation, at such intervals as will preserve the swallowing capacity.

Intubation.—The lumen of the œsophagus may be maintained by a tube passed through the growth and left *in situ*. This is the method of intubation introduced by Charters Symonds, though the gum-elastic tubes which he used have now been superseded by the spiral silver wire tubes of Souttar, which may remain in place unobstructed for several months. The stricture is first examined through a wide-bore œsophagoscope and the lumen is found, and dilatation carried out with graduated bougies or a bag. A fine guide is introduced, and on it is threaded the flexible intubation tube, to be inserted through the stricture by means of forceps or a special tubular introducer.

A collar on the upper end prevents the tube from slipping through the growth, while the spiral structure of the instrument prevents its expulsion. A fairly thick varied diet can be taken, provided that lumpy food is avoided. All food must be taken finely divided, otherwise the tube gets blocked. The tube may slip through the stenosis, owing to its dilating effect, or the carcinoma may grow exuberantly and obstruct its upper end. Even though the tube slips out of place and passes into the stomach, no untoward symptoms should arise, as it will traverse the intestinal tract without difficulty; there is the disadvantage, however, that another tube must be inserted..

Methods of irradiation give, in our hands, better results and are therefore to be preferred.

Diathermy.—It is possible to pass an electrode, shaped like a bougie, through a carcinomatous stricture and, while drawing it back, to coagulate and destroy part of the growth, but the effects are uncertain and the results poor; the method cannot be recommended.

Irradiation.—Irradiation by radium or X-rays may be expected to destroy an œsophageal carcinoma if applied suitably. The difficulty is to apply the rays efficiently to all parts of the growth in a concentration sufficient to destroy all malignant cells without excessive injury to surrounding healthy tissues. There are two principal methods of using radium: (1) superficial and (2) interstitial. Some years ago the first method was in vogue; a silver capsule containing 50 or 100 mg. of radium was introduced into the lumen of the growth, where it remained for several hours. It was difficult to ensure correct application and the results were uncertain and generally disappointing. Various modifications have been adopted; in one the radium was carried in a gum-elastic intubation tube provided with a collar, while in another the railroad, or thread-guided method of introduction was employed. In later years an intubation tube of Souttar's type was used with radium needles or radon seeds fixed to its outer surface; here again the results were unsatisfactory. In our hands all such methods were uncertain in their results and have now been supplanted.

In an attempt to apply the second method the outer surface of a carcinoma may be irradiated by the introduction of radium needles or radon seeds, placed in position after exposure of the œsophagus by the trans-thoracic route, but this necessitates a dangerous operation, and to be really effective the exposure would have to be bilateral. In the cervical segment of the œsophagus, it is possible to attain good disposition of the radium, and certain cases of post-cricoid carcinoma have been treated in this way with success. In this region excision is preferable, but, if this is not practicable, distance irradiation may be used.

Interstitial irradiation, carried out from the lumen of the œsophagus, is a satisfactory palliative method and appears to us to be the method of choice in all except a few selected cases. If suitable means of exposure and introduction are used, there should be little risk of doing harm, while on the other hand the prospect of re-establishing the power of swallowing solid food is excellent. The patient eventually dies of asthenia, extension to the lungs or, in many cases, of the consequences of perforation of the trachea or left bronchus. The latter usually leads to rapidly progressing septic bronchitis or pneumonia, with a speedy and usually a painless termination.

Technique of intra-œsophageal radon implantation.—The radon seeds may be placed in series or in chains. After the usual physical and radiographic examinations, an œsophagoscope of wide lumen is introduced to expose the growth ; as this is, more often than not, in the middle third of the œsophagus, a tube 35 cm. in length is suitable. Having determined the extent of the growth and its distribution around the lumen of the gullet, it is next necessary to find the lumen, either with a fine bougie or with a flexible-ended dilating bag. The stricture is dilated sufficiently to allow the passage of a large-sized bougie of Jackson's type. This is drawn up until its shoulder impinges against the lower end of the growth. The length of stem projecting from the mouth of the œsophagoscope is then measured, and the bougie is drawn up until its shoulder appears at the top of the growth. The stem is again measured, and the difference between the two readings gives the length of the stricture, usually 4 or 5 cm. The growth itself may, of course, extend up or down in the lymphatics of the walls without producing stenosis. This possibility must be allowed for by irradiating a rather longer segment than that indicated by the measurement.

Radon seeds are implanted by a long hollow introducer with a sharp, bevelled point and an accurately-fitting stylet. On this introducer is carried a sliding collar which can be placed at the required depth so as to show when the introducer has been thrust down as far as the lower end of the growth. Seeds can be implanted first into the lower and then into the upper parts of the growth in such a way that the centre of each seed lies 1 cm. away from the centre of its neighbour. The seeds are placed in columns around the periphery of the carcinoma according to its extent ; either three or four columns are required.

We have introduced a method of implantation of linked radon seeds. The object is to lessen the difficulties of placing a series of individual seeds in correct position, and to ensure maintenance of the seeds in position once they have been implanted. The growth is inspected and measured as described. The length of the region actually narrowed is slightly exaggerated in estimating the area to be treated, to allow for irradiation of any possible infiltration above and below the structure. Chains of radon seeds are then prepared, the length and number depending on the extent of the neoplasm. Each seed is of 1·3 mcr. screened with 0·5 mm. gold ; its length is 0·6 mm. The chains are made up by linking seeds together with short strands of catgut, which are screwed into the open ends of the gold screens.

If the area to be irradiated is 5 cm., 5 seeds are joined, each link being 0·4 cm. The centres of the individual seeds are thus 1 cm. apart. Either three or four columns are used, according to whether the growth completely encircles the œsophagus or only involves threequarters or less of the periphery. In hospital practice it is possible to save expense by loading the seeds into thin tubes of silk or rubber, separated by beads. To the upper end of each column a bead is attached, to aid removal after a suitable interval.

Having determined these points, and being provided with the requisite columns of seeds, a wide œsophagoscope is introduced and the growth exposed. An introducer, at least 6 cm. longer than the œsophagoscope, is loaded with a column of seeds. A sliding indicator on the introducer is placed to show the requisite depth ; if the growth is 5 cm. long it should be set at 5·5 cm. The column of seeds should, in such a case, be 6 cm. long. The seeds are held in position by a stylet locked by a screw on the projecting end of the introducer. The head and shoulders of the patient are placed in such a position that the œsophagoscope is directed in the exact axis of the œsophagus. In the upper thorax, the direction is slightly backwards towards the spine ; in the middle zone it is parallel with the spine ; and at the lower end it is a little forward and also to the left, the tube pointing towards the left anterior superior iliac spine. The introducer is then thrust into the growth until the depth indicator touches the upper surface ; the most dependent part is treated first, to avoid obscuration by blood in the subsequent stages.

When the seeds are in position the introducer is withdrawn. To prevent displacement of the column of seeds, the stylet is immobilized by an adjustable arm temporarily attached to the œsophagoscope ; thus the outer tube slides off the seeds. Two or three more columns are implanted, at distances of about 1 cm. apart. (Fig. 715.) If the chains of seeds are coupled by catgut, they should be left in place, but if silk tubes have been used the columns are retrieved by direct œsophagoscopy at the end of ten days, the attached beads indicating their position. The object of removal is to avoid irritation by the silk container and to retrieve the gold screens.

There is practically no local reaction or general disturbance after the implantation. Improvement of swallowing should follow immediately and may last for as long as one or even two years. A second examination may be required, when it may be found that there is a cicatricial stricture requiring dilatation, or that further radon treatment is necessary.

Some surgeons have found difficulty in implanting radon seeds into the lower parts of a growth and have therefore utilized *retrograde œsophagoscopy*. In this method an œsophagoscope is passed from below, after opening the stomach, and seeds are inserted through it, while others are introduced from above, as already described. As the whole growth can usually be irradiated from above, the abdominal operation does not appear necessary or justifiable.

Deep therapy.—The inaccessible position of the thoracic œsophagus makes distance irradiation difficult. Multiple portals of entry must be utilised, but even with the protracted fractional method there is danger of damage to the lungs. But successful results have been recorded and it is to be hoped that, with improved apparatus and more accurate technique, satisfactory results may eventually be obtained by this method. Interstitial irradiation by the method described is simpler and involves the patient in less discomfort than the lengthy treatment necessary with deep therapy, but it is possible that a combination of external and internal irradiation may ultimately give better and more lasting results.

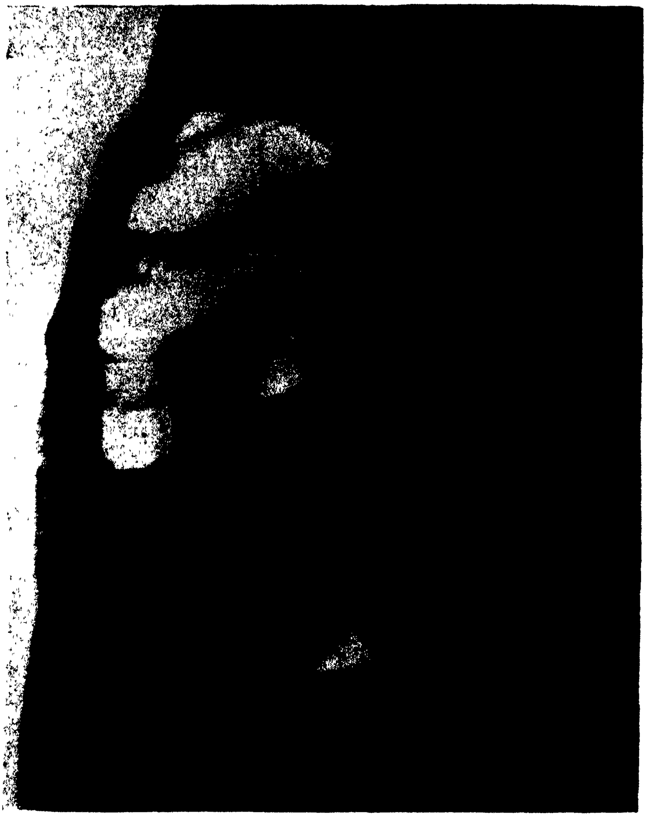

Fig. 715.—Radon seeds in position in a growth.

Gastrostomy is the means by which the principle of short-circuiting is carried out. Not only does it enable the patient to receive sufficient nourishment but it protects the growth from the traumatism and sepsis incidental to the passage of food. To get the best results, it is essential that the operation should not be too long delayed and that the patient should be fed on a properly balanced mixed liquid diet. For psychological reasons some fluid nourishment should be permitted by the mouth as long as the patient can swallow. In order to keep the lumen of the growth free from débris and mucus it is a good plan to allow the patient to sip small quantities of a solution of peroxide of hydrogen, of a strength of 1 in 10, at frequent intervals.

Gastrostomy may be desirable in certain cases where the trachea or bronchi are invaded and perforated by the growth and where great distress is caused by attempts at swallowing. It is also a necessary preliminary to œsophagectomy. The technique of the operation is described at p. 743, Vol. I.

ŒSOPHAGECTASIA

ACHALASIA ; CARDIOSPASM ; PHRENOSPASM

Method of treatment.—

1. Removal of stagnant secretions: (*a*) with stomach tube; (*b*) through œsophagoscope.
2. Dilatation from above: (*a*) under direct vision through œsophagoscope: (i) with bougies; (ii) with dilating bags; (iii) with expanding metal dilators; (*b*) autodilatation with mercury bougie; (*c*) thread guided method; (*d*) with fluoroscopic guidance.
3. Dilatation from below with fingers after gastrostomy.
4. Œsophagolysis.
5. Plastic operation on lower œsophagus: (*a*) Heller's operation; (*b*) cardioplasty.
6. Short-circuiting by œsophago-gastrostomy: (*a*) abdominal route; (*b*) thoracic route.
7. Denervation of sympathetic nerve supply.

Thus, the surgical treatment of this condition may take many forms, depending on the various interpretations of the pathology of the disease. When surgical treatment is not contemplated, periodic **removal of the stagnant food** by syphoning and lavage with a stomach tube or by occasional suction through the œsophagoscope is of great help as a palliative measure, as it makes the patient more comfortable and counteracts the tendency to œsophagitis. As the condition is not fatal, life may be carried on in comparative comfort with the help of permanent gastrostomy.

Dilatation as a method of treatment is usually only a palliative measure, though one of great value. For this purpose Hurst's mercury bougie is most effective. The tube is lubricated with paraffin or olive oil and is easily swallowed after a short training. In uncomplicated cardiospasm it always gives great relief and in some few cases is curative. Preliminary dilatation under the guidance of the eye through the œsophagoscope may be of considerable help. The narrowed part just at the diaphragmatic hiatus may be stretched widely with bougies or a dilating bag, after clearance of all food débris from the gullet. Subsequently, the daily use by the patient of a mercury bougie, as advocated by Hurst, may relieve symptoms.

For dilatation with an expanding bag a wide-bore œsophagoscope is necessary if a large bag is to be passed under direct vision; the circumference of the instrument preferred is 60 mm. (see p. 1475). The head and shoulders of the patient must be well depressed to expose the diaphragmatic hiatus, but in most patients it is possible to obtain a clear view, even with so large an œsophagoscope. A small dilating bag on a hollow stem with a flexible end is first passed, and in most cases no obstruction will be encountered. Sometimes there is considerable kinking of the œsophagus as it passes through the diaphragm, owing to elongation and sagging-down of the lower segment to a level lower than that of the actual hiatus; the flexibility of the dilator usually overcomes this difficulty. The small bag is distended to its full extent and is then withdrawn and followed by a larger cylindrical dilator, also mounted on a flexible attachment: If its passage is obstructed, it is helpful to pass a thin flexible bougie into the stomach and to slide the bag down this guide; an instrument of this type is illustrated in Fig. 702, p. 1493. By this direct method wide dilatation may be obtained, with a good result in most cases.

Expanding metal dilators of umbrella type may be used under direct vision if passed through an œsophagoscope; in our opinion dilating bags are preferable. Preliminary stretching with a bag, followed by the passage of mercury bougies, appears to have advantages also over the *thread-guide* method or the *fluoroscopically-guided dilators* of Mosher.

If the condition cannot be treated by one of the oral methods of dilatation, it will be necessary to carry out some operative interference conducted from the abdomen. Patients who require this type of intervention are often in a poor state of nutrition, and in these circumstances it is much wiser to perform a preliminary gastrostomy. As a result, not only does the general condition rapidly improve but the local obstructive lesion may also be ameliorated and, after a time, measures of dilatation from above which previously failed may be practised with success.

The surgical measures to be employed on the lower œsophagus may take the form of: (1) digital dilatation or (2) some type of plastic operation.

Digital dilatation of the lower end of the œsophagus (Mickulicz).—
—The abdomen must be opened and the stomach explored, to exclude any lesion such as gall-bladder disease or gastric ulcer, to which the œsophageal condition might be secondary. The stomach is opened at some accessible part on its anterior wall, not too far from the cardiac end. The incision should be sufficiently large to admit the whole hand. Vessels in the gastric wall must be caught and tied.

In order to avoid soiling the abdomen, a wide purse-string suture should be placed round the opening in the stomach wall and loosely tied around the fingers or hand, while the manipulations are in progress. As a rule the first finger will enter the cardiac canal with comparative ease and, if that is so, eventually three fingers may be inserted like a cone, and passed up the œsophagus as far as the knuckles.

Once the resistance is felt to be giving way it is usually not difficult to complete the dilatation.

As soon as the obstruction is overcome, there may be a sudden gush of fluid from the œsophagus into the stomach. As some of this may escape by the side of the hand it is important at an earlier stage to have the stomach well packed round by gauze to protect the abdomen, and to have a reliable suction apparatus in readiness.

It is essential to realize that, while steady pressure is necessary, no great force must be used and, unless the operator feels that the obstruction is yielding, he must not exercise such force as might cause tearing. If there is a tear, it will be recognized by the sudden relaxation. Should this happen, the operator must withdraw his fingers and must carefully inspect the abdominal œsophagus from the outside. If there is evidence of a tear, it must be repaired by suture and the area further protected by stitching a portion of omentum over it. Though this accident is alarming and serious, many cases in which it has occurred have recovered. Dilating instruments have been devised but they are not as reliable as the fingers. After the dilatation the stomach must be carefully closed. The patient may be fed by the mouth from the first, the gradation from sips of water to an ordinary diet being spread over a period of a week or ten days.

The results of this method are said to be very good. Deaths immediately following the operation have been recorded, but have usually been due to unrecognized tearing of the œsophagus, or to the very poor condition of the patient at the time of operation. In some few patients there has been a tendency to recurrence which can usually be arrested by subsequent resort to loaded bougies passed by the mouth. Many patients observed over a period of years have remained free from symptoms. In a series of 89 cases treated by Sir James Walton 64.2 per cent. were cured, 17.9 per cent. obtained incomplete relief and 9.75 per cent. (4 cases) died.*

Œsophagolysis.—Good results may be obtained from this operation in certain cases, particularly when elongation of the dilated œsophagus is associated with kinking. The technique is similar to that of exposure (p. 1483). After freeing the gullet from the margins of the diaphragmatic hiatus and pulling it down into the abdomen, upward displacement is prevented by anchoring sutures inserted into the diaphragm and liver.

Plastic operations on lower œsophagus.—For these interventions an adequate exposure is essential. This requires a suitable parietal incision and mobilization of the left lobe of the liver. In January, 1913, Adrien Lambert, an American surgeon, published a description of the method of exposing the lower end of the œsophagus by separating the left lobe of the liver from the diaphragm. This method has been modified and often used by one of us (Grey Turner) and was described and illustrated in the Bigelow Lecture for 1931. The operation is conducted under general anæsthesia with the patient in the reversed

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* A. J. Walton, *Brit. Journ. Surg.*, 1925, xii, 701, and private communication.

Trendelenburg position. A long median incision is made, commencing in the angle between the left border of the ensiform and the costal margin and carried down to, or a little below, the umbilicus. The upward extension of this incision is the most important feature of this approach. A long, oblique incision parallel with and just below the left costal margin has also been recommended. The next step is to take hold of the left lobe of the liver and to draw it downwards, thus exposing the left lateral ligament, which is always very well defined and has an especially sharp left margin. (Fig. 716A.) The ligament is divided with scissors along its centre and for its whole extent. By this manœuvre, the left lobe is completely mobilized and may then be either lifted out of the incision and held over to the right by some type of retractor, or, if not too bulky, it can sometimes conveniently be packed under the right side of the abdominal wall where it can be held out of harm's way by a broad retractor. The stomach is then drawn well downwards, when an excellent view of the intra-abdominal œsophagus, covered by peritoneum, will be obtained. Using a syringe armed with a long, fine needle, about two ounces (60 c.c.) of 1 per cent. novocain is injected into the cellular tissue surrounding the lower end of the œsophagus. The overlying peritoneum is then divided transversely at the point where it is reflected from the diaphragm on to the œsophagus (Fig. 716B). A vessel which is always found running across in front of the hiatus must be carefully avoided or ligatured. The finger can now be introduced into the diaphragmatic hiatus, and can easily be worked around the œsophagus, which can readily be separated from its cellular bed up to the highest point which the finger can reach. With the finger hooked round the œsophagus, quite firm traction can be safely made and it can usually be drawn down into the abdomen to an appreciable extent (Fig. 716C). Unless it is elongated as the result of obstruction or is of the sinuous type, it is not usually possible to expose more than 2 to 2½ inches in this way. The lower œsophagus is now available for inspection and investigation. After the necessary intervention has been carried out the left lobe of the liver is allowed to fall back into position and does not require to be fixed by suture, but, if thought necessary, it may be attached to the œsophagus by a penetrating suture. In a similar way it may be attached to the edges of the hiatus.

Heller's operation.—In its scope and plan this operation is strictly parallel with the Rammstedt operation for congenital hypertrophic stenosis of the pylorus. The abdominal portion of the œsophagus is exposed and a vertical incision is made along its anterior surface including the junction with the stomach. This incision must be at least 1½ inches long, and half of it must be situated on the œsophagus proper, and the other half on the stomach wall. The incision goes through both longitudinal and circular muscle fibres and is deepened until the submucous bed is reached. The muscular fibres are then encouraged to retract by a little blunt dissection

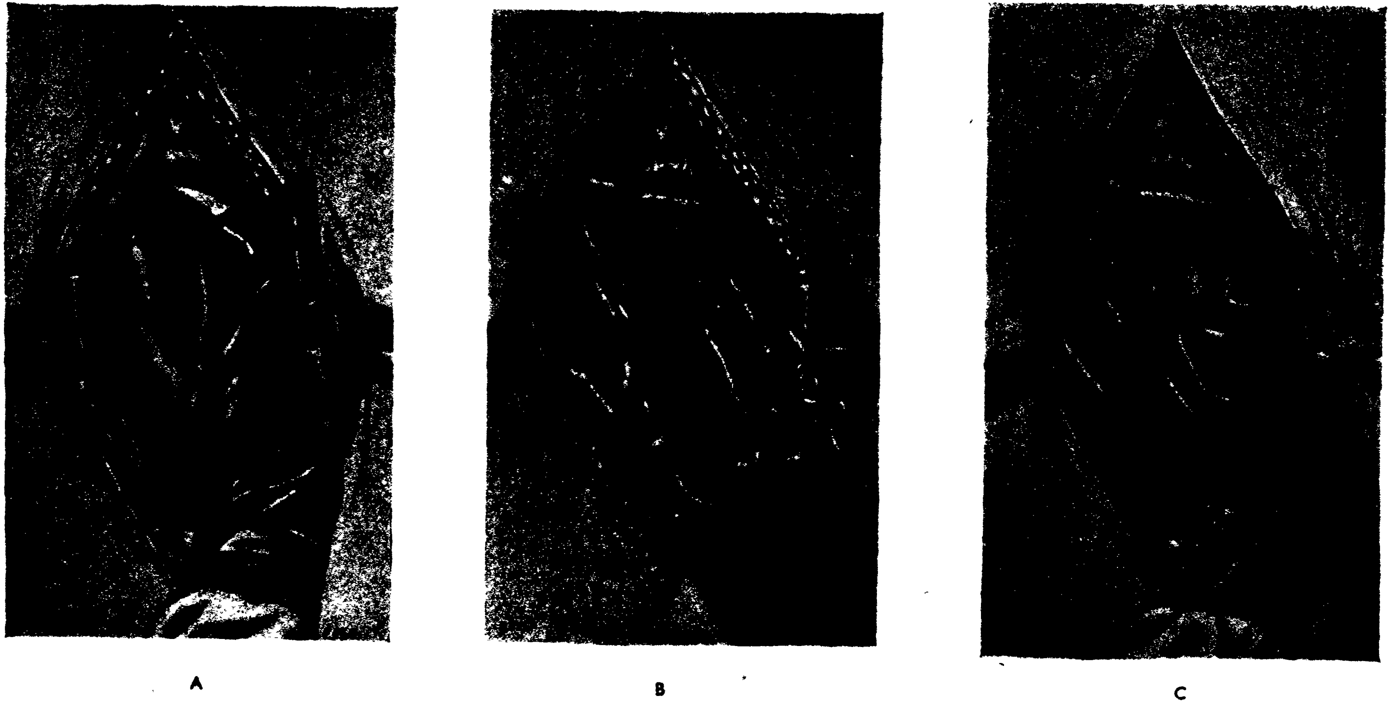

Fig. 716.—Exposure of lower end of œsophagus through an upper abdominal incision.

A. The left lateral ligament of the liver before division. B. The ligament has been divided and the left lobe of the liver turned aside. Dotted line indicates site for incision of over-lying peritoneum. C Œsophagus has been mobilized by the finger which is shown hooked behind it.

with the handle of the knife or gauze stripping. The mucous membrane should freely bulge into the gap but is not to be incised. In some cases the vertical incision becomes more or less diamond shape, and it is only when this occurs that the operation is likely to be entirely successful.

Cardioplasty.—In this operation a similar vertical incision is made through the junction between the œsophagus and stomach but the lumens of both viscera are freely opened. The incision is then sutured in the opposite direction. The interference is comparable with the operation of pyloroplasty, and its principle is sufficiently indicated in Figs. 717, 718. The incision through the œsophageal wall should be from 1½ to 2 inches long, depending upon the size of the parts to be dealt with, but whatever its length the centre should be at the situation of the stenosis. It is usually convenient to make the incision in its entirety down to the mucous membrane, and then to make a small opening through the latter at the lower end. In this way any sudden flooding of the parts with gastric or œsophageal contents can be avoided, and what does escape can be removed with the suction apparatus or mopped up with gauze. The mucous membrane is then divided throughout the whole length of the incision. Some few vessels will have to be caught and ligatured.

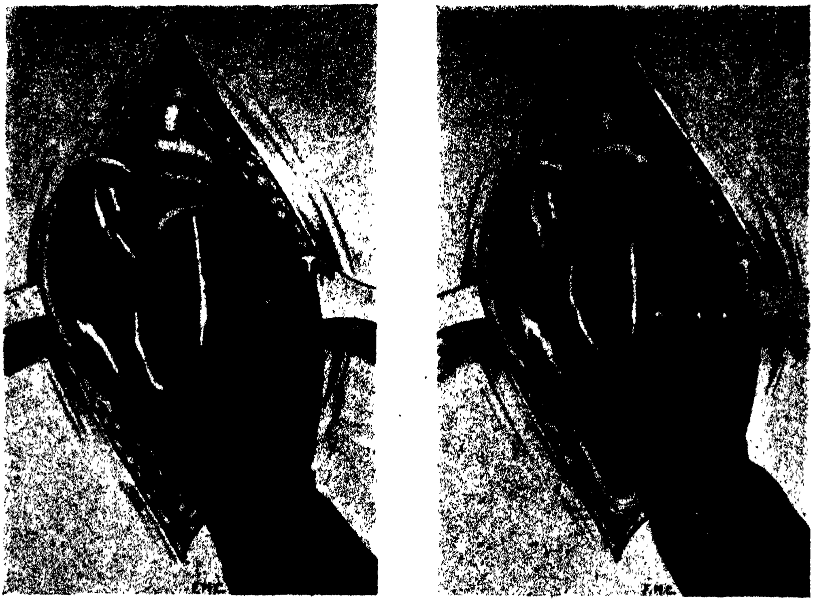

Fig. 717.—Mobilization of lower part of œsophagus by finger working in the cellular tissue of the œsophageal tunnel. The finger can be introduced right up to its metacarpo-phalangeal joint.

The closure is begun by suture of the mucous membrane. The extremities of what was the vertical incision are first drawn together by an interrupted guide stitch and the closure is completed by continuous sutures commencing at either end and finishing up at the central guide stitch. This suture should be hæmostatic and watertight. The muscular walls are drawn together over the mucous membrane by a series of interrupted sutures. These must go through both layers of muscles and must take a good bite and be very gently approximated and tied or they will probably cut out. As a third series, a few sutures are used to close up any gaps and to draw any loose tissue in the vicinity over the suture line.

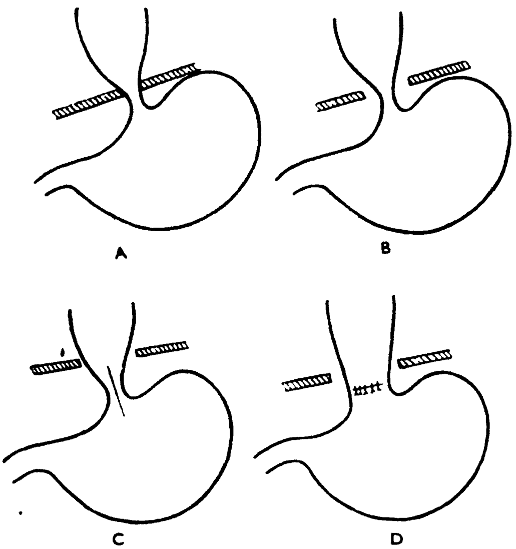

Fig. 718.
A–B. Mobilization of lower end of œsophagus as in Fig. 717. C. Vertical incision through stricture. D. Incision sutured transversely showing consequent broadening of œsophagus.

Short-circuiting: œsophago-gastrostomy.—(*a*) **The operation from below the diaphragm.**—The œsophagus is exposed and mobilized as already described. It is not easy to control the area of anastomosis withclamps, and these are really not essential, but if the stomach is bulky or somewhat distended a clamp may be placed across the upper part in such a way as to shut off the area of anastomosis. The left side of the œsophagus can now be approximated to the fundal end of the stomach, as shown in Fig. 719. As a first step in the anastomosis a posterior layer of interrupted or continuous sutures is applied between the bare muscular wall of the œsophagus and the peritoneum-covered stomach. The wall of the œsophagus is very friable and stitches easily cut out, and for that reason they must not be drawn tight ; easy approximation is all that is required. The opening in the œsophagus is made obliquely, or both it and the stomach may be incised after the manner of the Finney pyloroplasty. It is usually possible in the first case to incise the muscular walls of both œsophagus and stomach without opening into the lumen of either, and in that case the posterior muscular layers are approximated with a few interrupted sutures. The mucous membrane of the œsophagus is very lax and bulges between the edges of the cut muscle. In the first instance only a small opening is made. When the mucous membrane is incised, an accumulation of fluid in the gullet may be very troublesome, and the surgeon must be prepared with the suction apparatus and ample gauze protection. A small gauze may be packed into the opening and left until the suture is nearly completed. It is important to make the anastomotic opening of sufficient size, and certainly not less than an inch and a half in length. The suture uniting the mucous membranes of the stomach and œsophagus must be continuous and of catgut, and anteriorly it may include the deeper layer of the muscular coats. The anterior external layer of sutures must also take a good hold of the muscle and is better interrupted. It is important that one or two additional stitches should be placed at either end beyond the anastomosis. The left lobe of the liver is replaced in position and fixed to the stomach just below the anastomosis by a mattress stitch. This not only protects the union by acting like a graft, but is also a means of anchoring the mobilized lobe. If there is any doubt about the security of the suture line there need be no hesitation in bringing a small rubber drainage-tube from the region of the anastomosis out through the parietal incision. No special after-treatment seems necessary. Most of the cases have been operated upon in the presence of gastrostomy, so that during convalescence feeding could be carried out entirely by that route. In its

Fig. 719.—Anastomosis of lower end of the œsophagus with the stomach.

absence the patients have been allowed to have sips of water from the first, and if that can be swallowed without discomfort, liquid nourishment is administered. Otherwise, for the first few days rectal and intravenous alimentation must be used. Leakage with sub-diaphragmatic abscess is the complication most to be feared.

(b) Operation by the thoracic route.—This operation was first carried out through the chest and this route may still be necessary when, for instance, it is proposed to make the union between a diverticulum of the thoracic œsophagus and the cardiac end of the stomach. The preliminary stages are the same as for transthoracic œsophagectomy.

The œsophagus is readily exposed below the root of the lung by dividing the overlying pleura, and may be separated from the cellular tissue with the finger. If the œsophagus is much dilated or if there is a diverticulum, it is better not to separate the whole œsophagus from its bed but merely to expose the part that is to be used for the anastomosis. The area can be demarcated by inserting a couple of guide sutures. The fundus of the stomach is then exposed by incising the diaphragm through its summit, commencing the incision about an inch and a half in front of, and external to, the hiatus and making it about two inches in length. A cone of stomach, as free from vessels as possible, is then drawn up into the chest and may be grasped by a curved stomach clamp. Sometimes such a clamp can be applied to the portion of the œsophagus selected for the anastomosis, but this is not essential.

Before sutures are inserted the pleura should be protected from contamination by gauze packs soaked in 1 : 1,000 acriflavine. The next step is to approximate the œsophagus and the cone of the stomach and to suture them together by a posterior Lembert suture. This stitch has often to be interrupted because of the friability of the œsophageal wall. The opening into the lumen should be 1½ inches in extent. Steps must be taken to prevent flooding of the operation area with œsophageal contents. Nevertheless it is wise to make only a very small incision into the lumen to begin with so that escaping contents can be controlled by the suction apparatus. The main approximation is made with a continuous suture through all the coats. Great care should be taken to protect this with further interrupted sutures passed between the muscular wall of œsophagus and stomach. With the final protecting stitch, the mediastinal pleura may be tacked to the œsophagus, the same stitch catching up the peritoneal coat of the stomach. If the cellular tissue has been soiled it should be smeared with Bipp. If the opening in the diaphragm is obviously too free there is a risk of hernia and it should be diminished by sutures at the extremities, but care must be taken not to constrict the stomach cone. The base of the cone of the stomach should be attached to the edge of the incision in the diaphragm. The surgeon must use his judgment as to whether he leaves a drain in the pleural cavity ; the present practice is in favour of drainage.

Denervation of lower end of œsophagus (Knight's operation).—As the result of experimental work Knight concluded that achalasia was probably due to over-action of the parasympathetic fibres on the lower œsophagus. Acting on this assumption, he endeavoured to remove the cause by excising the œsophageal branch of the left gastric artery with the accompanying parasympathetic fibres to the lower end of the œsophagus. In animals this appears to have worked successfully, and symptoms of experimentally produced cardiospasm disappeared. The operation has now been given a fairly extensive trial in human beings, but the reports are variable, and the general impression is that denervation cannot always be relied upon to bring about relief. Nevertheless one of us has been impressed with the fact that patients apparently cured of achalasia, whether by dilatation, or by plastic operations, do suffer occasionally, even after the lapse of years, from attacks of difficulty in swallowing, presumably due to spasm. It would, therefore, seem reasonable to combine such operations with excision of the left gastric artery in the hope that this denervation would contribute to removing the mechanism for the production of spasm.

ŒSOPHAGEAL VARIX

This condition is usually the result of cirrhosis of the liver or one of the phenomena associated with splenic anæmia. It may not disappear after splenectomy, and deaths from œsophageal hæmorrhage have occurred after this operation. Some cases of varix have been treated by coagulating injections or diathermic coagulation carried out through the œsophagoscope. In other cases, the left coronary vessels have been ligatured with arrest of hæmorrhage and, it is said, without recurrence.

Technique.—The abdomen is opened by a high epigastric incision and the coronary vessels are sought at the highest part of the lesser curvature as they approach the œsophagus. They should be isolated and divided between double ligatures.

ŒSOPHAGO-TRACHEAL OR BRONCHIAL FISTULA

When this condition is the result of malignant disease in the cervical œsophagus it may, on some rare occasions, be so localised as to justify an attempt at excision of the parts involved. As a general rule, it is only in non-malignant conditions that operative interference may have to be considered. When the condition results from an abscess or the long-standing impaction of a foreign body, healing may follow the removal of the cause, though it may be a slow process. Sometimes the rest provided by gastrostomy may assist spontaneous closure. In operative interference the principles that must guide the surgeon are : first, the necessity of separating the two structures so that they may be independently repaired by suture, and secondly, the provision of physiological rest during the process of healing by temporary gastrostomy.

In the neck the area may be approached as already described (p. 1484) for the operation of œsophagotomy. When situated in the thoracic œsophagus the posterior mediastinal or trans-thoracic route will have to be followed. During the process of separation the communicating aperture may be torn much larger. If the edges are indurated they should be excised. In closing the aperture in the œsophagus the sutures must be inserted across the lumen and not in its length, in order to avoid narrowing. Any soft tissue in the vicinity should be drawn over the area to fortify the suture line. A whole-thickness skin graft has been employed to assist in the repair of the tracheal or bronchial fistula (V. E. Negus). In any event, external drainage must be provided. Some degree of subsequent narrowing is almost to be expected and must be treated by early resort to bougies.

Though the condition is serious, successful results from operation have been reported.

ŒSOPHAGOSTOMY

In this operation the œsophagus is opened in the lower part of the neck and the margins stitched to the skin surface. As a method of short-circuiting a growth in the mouth or pharynx, it has been entirely superseded by gastrostomy. It is sometimes employed as a means of ready approach to a non-malignant stricture high in the mediastinal œsophagus. Occasionally it may be required as the first step in the operation for the construction of an ante-thoracic gullet (see p. 1499). The œsophagus is exposed and opened as described for œsophagotomy, but the edges of the incision are sutured to the margin of the skin incision. The opening should be large enough readily to admit the forefinger. To diminish the risk of contraction, the œsophageal edges should protrude a little beyond the skin margin.

CHAPTER XXXIV

OPERATIONS ON THE LIPS, JAWS, MOUTH, TONGUE AND SALIVARY GLANDS, TOGETHER WITH METHODS OF TREATMENT BY IRRADIATION

By A. J. GARDHAM

ANATOMICAL CONSIDERATIONS

ACCURATE appreciation of the size and shape of the tongue is useful in planning local operations, and essential to any surgeon who proposes to use interstitial irradiation. Fig. 720 demonstrates how erroneous is the impression that the tongue is simply a mobile muscular organ which lies free in the floor of the mouth.

In size it varies within very wide limits, according to, and to some extent independently of, the stature and build of the patient, in response to his constitutional state.

Its shape is complicated. The lowest point in the neck to which it extends is the hyoid bone. Seen in section at this point, the tongue consists of a thin muscular sheet corresponding in shape to the hyoid

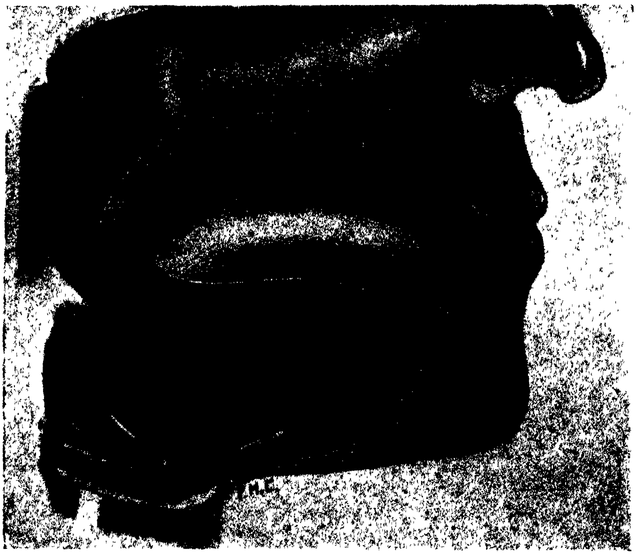

Fig. 720.—Muscles forming the base of the tongue.

A, hyoid bone ; B, genio-hyoid ; C, hyoglossus ; D, genioglossus ; E, styloglossus, oblique and longitudinal portions.

bone, lying comparatively superficially in the neck, and quite inaccessible from the mouth. Reinforced from in front by the fibres of the genioglossus, and from behind by those of the styloglossus, the thickness of the organ rapidly increases, and in its middle third reaches perhaps 3 or 4 cm. before it diminishes again towards the tip. The thick part of the tongue extends only about ¾ cm. to either side of the mid-line; followed laterally beyond this, the extent of the organ is no greater than that appreciated from within the mouth.

The rest of the floor of the mouth is occupied by the submaxillary and sublingual salivary glands, the mylohyoid and digastric muscles, and the submental and submaxillary lymph glands. Posteriorly the digastric muscle and the submaxillary salivary gland are in contact with the carotid sheath, and at this point there is no clear division between the structures of the floor of the mouth and those of the carotid triangle of the neck.

The close relation of Wharton's duct and the lingual nerve to one another, and to the mucous membrane of the floor of the mouth, is important, and should always be kept in mind in operations involving this region.

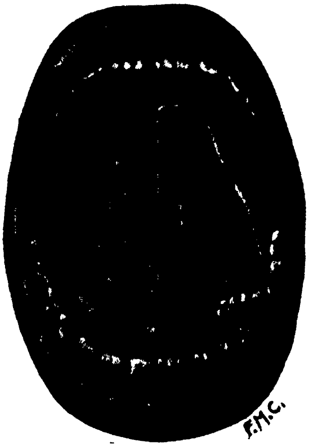

Fig. 721.—Course of the lingual artery.

Blood supply.—The structures within the buccal cavity are normally supplied almost entirely by branches of the external carotid artery and, if preliminary control of the circulation is required, ligature of the external carotid is the best method. In dealing with vascular tumours it must be remembered that abnormal anastomoses have usually been established, and ligature of the main vessel to a tumour may not diminish its circulation materially. Even where a temporary diminution takes place, circulation often re-establishes itself completely in a very short time, and such procedures as ligature of the labial artery or arteries as a method of treatment for angioma of the lip are very unlikely to be successful. In very vascular tumours such as cirsoid aneurysms, ligature of both external carotids may fail completely to control the bleeding owing to the extensive anastomoses which have been established with the vertebral artery.

The course of the lingual artery in the substance of the tongue is of some importance to the surgeon (Fig. 721), as he may wish to secure it when performing an intrabuccal excision. After it emerges from beneath the hyoglossus it runs close to the mucous membrane of the under surface parallel with the lateral margin and about two-thirds of the distance from it to the frænum. Owing to its tortuous course, it can often be seen and secured before it is divided, particularly if traction is being made on the anterior part of the tongue. The "classical" ligature of the lingual artery beneath the hyoglossus is not a good operation, as the dorsalis linguæ which originates beneath the hyoglossus and passes to the dorsum of the posterior part of the tongue may originate far back, and so escape occlusion. Moreover, some part of the blood supply of the posterior part of the tongue is derived from the facial artery, and ligature of the lingual anywhere in its course does not completely control hæmorrhage in operations involving the posterior third.

There is no free vascular anastomosis across the middle line of the tongue and, once the correct plane is found, the tongue can be split from its tip to the epiglottis with very little bleeding.

The facial artery, shortly after it leaves the external carotid, comes into intimate connection with the submaxillary salivary gland, and operations which involve the removal of the gland generally require division of the artery.

Nerve supply.—**Sensory.**—The chief sensory nerves in the buccal cavity are the trigeminal and the chorda tympani which joins its lingual branch. In addition, the glossopharyngeal nerve supplies the pharynx and posterior part of the tongue for both taste and ordinary sensation. The lingual nerve in the last part of its course lies very close to the mucous membrane of the mouth, and in intimate relationship with the duct of the submaxillary gland. In this situation it may be infiltrated with novocain if anæsthesia of the front of the tongue is required. It is also liable to injury here, particularly while the surgeon working from the neck is freeing the deep portion of the submaxillary gland. Division of the lingual nerve is a serious matter, as it produces anæsthesia of one side of the tongue, so that it may subsequently suffer from repeated and unnoticed injuries.

Motor.—The motor branch of the fifth nerve supplies the muscles of mastication. The tongue is supplied by the hypoglossal, and the muscles of the pharynx and soft palate by the bulbar part of the accessory nerve through the vagus.

Lymphatics of the buccal cavity.—**The tongue.**—The lymphatics of the tongue consist of a submucous plexus continuous over the whole surface and communicating with an extensive intramuscular plexus. The collecting vessels of the central part of the tongue may often be observed to cross the mid-line and drain into the glands of the opposite side of the neck. It is reasonable to suppose that this tendency to drain into the glands of the opposite side is increased where the lymphatic vessels of one side have been obstructed by growth or removed by operation.

There are three main groups of glands which receive lymph from the tongue. (1) The submental group, which lies between the anterior bellies of the digastric muscles between the hyoid and the jaw. (2) The submaxillary group, which lies in close relation to the submaxillary salivary gland and the facial vessels. It is important to note that one at least of these glands may be on the superficial surface of the jaw just in front of the masseter and close to the facial artery. Failure to appreciate this fact may leave this gland untreated and a potential source of recurrence. (3) The deep cervical group, lying along the jugular vein beneath, behind, and in front of the sterno-mastoid. Two sub-divisions of this group are of special importance : the jugulo diagastric group and the jugulo-omohyoid group. The former, as its name suggests, lies between the posterior belly of the digastric and the jugular vein and includes one large gland which clinically is very often affected in carcinoma of the tongue and has in fact been called the " principal lymph-gland of the tongue." The jugulo-omohyoid gland is situated on the vein at the point where the omohyoid crosses it. It receives lymph from all parts of the tongue, and some lymphatic vessels run directly to it. It may therefore be involved early, and it is of particular surgical importance because it is near the lower limit of the usual operation for the removal of malignant glands.

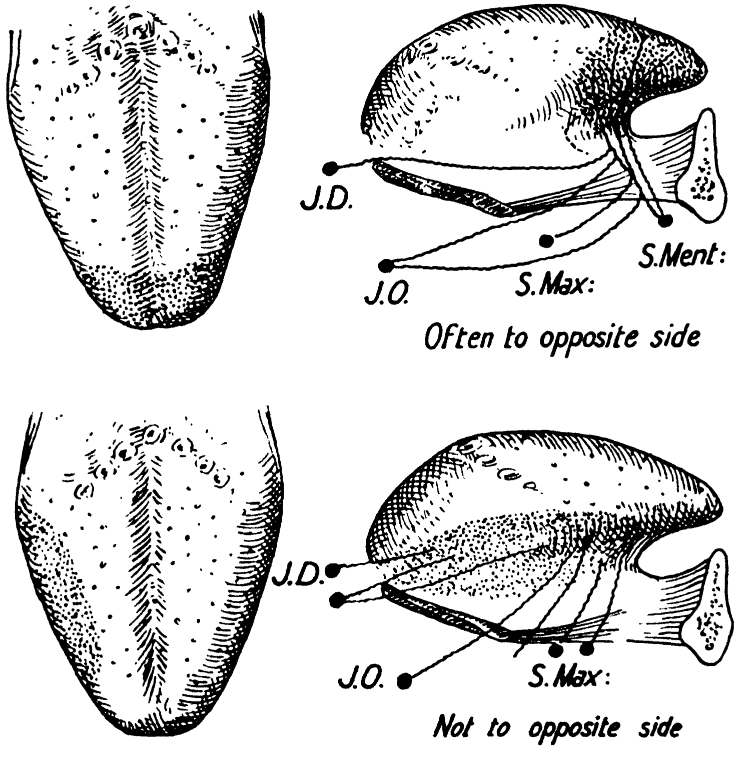

Fig. 722.—Lymphatic drainage of tongue, tip and frænal region and lateral margin.

The lymph drainage of the tongue may be divided into four areas :—

(1) The tip and frænal region.
(2) The lateral margin.

(3) The central area.
(4) The pharyngeal part.

Reference to Figs. 722 and 723 will show how the drainage from those areas passes to the various groups of glands. All three glandular groups receive lymph from all parts of the tongue, except that the area behind the circumvalleate papillæ apparently drains exclusively into the deep cervical glands. The vessels draining the tip and frænal region pass very close to the periosteum of the jaw on their way to the submental or submaxillary group, and operations for the removal of infected glands in this area are apt to fail unless particular attention is paid to this point. The efferents of the submental glands pass indiscriminately to the submaxillary and jugulo-digastric groups of either side; thus, a growth at the tip of the tongue may easily give rise to bilateral glandular metastases. There is no fixed line of division between the lateral and central drainage areas, but injection at a point a third of the way from the lateral margin to the middle line usually fills some of the central vessels, so it is clear that there are few growths which may not involve the lymphatics of the central area. This is

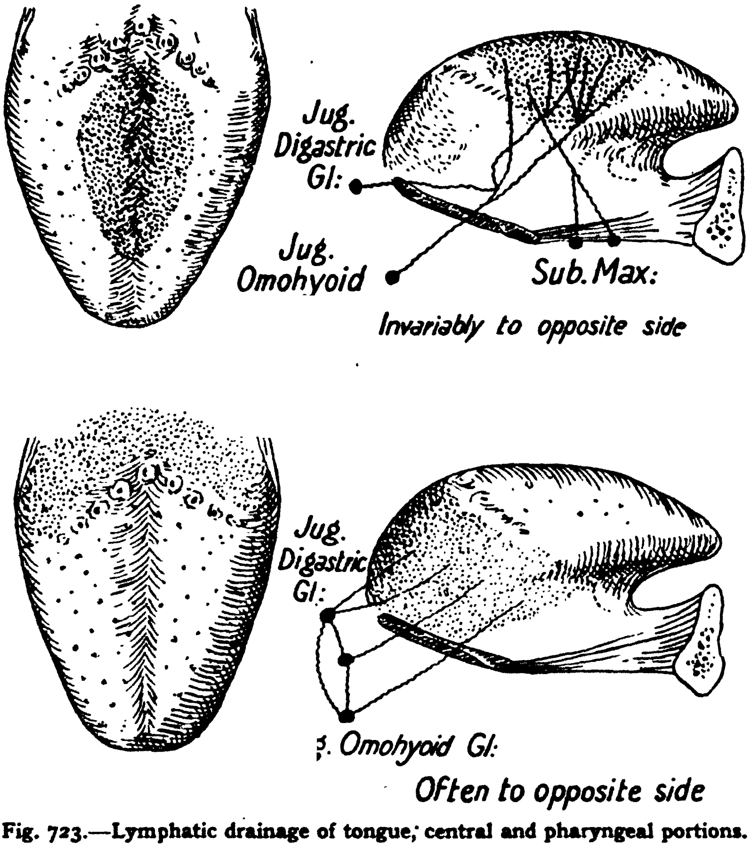

Fig. 723.—Lymphatic drainage of tongue; central and pharyngeal portions.

important, as many of the collecting vessels of this area cross the middle line to end in the glands of the opposite side of the neck. The drainage of the pharyngeal part (i.e. that part of the tongue behind the circumvalleate papillæ) is said to run exclusively backwards into the deep cervical glands, sometimes crossing the middle line. Clinically, however, secondary growth is often present in the submaxillary lymph glands when the primary growth is in the pharyngeal part of the tongue.

It must be emphasized that the glands of the deep cervical group receive much of the drainage of the tongue direct, and are consequently often infected before those of the submaxillary and submental groups. It must also be remembered, in planning the method of attack on a growth of the tongue, that the lymphatics of the genio-hyo-glossi may be infiltrated, and any method of treatment directed solely to the buccal part of the tongue may leave active growth in the lymphatics of the deeper muscles.

The buccal cavity.—Two more groups of glands must be considered in conjunction with the lymphatic drainage of the rest of the buccal cavity. The parotid lymph glands, which lie in the substance of the parotid salivary gland, receive some of the lymph from the posterior part of the gum. They may be involved as a result of growths in this situation, but fortunately such involvement is not common. Lymph glands also lie in relation to the internal maxillary artery, and it is probable that growths which infiltrate the pterygoid region also affect these glands. Their efferents pass to the deep cervical glands, and involvement of this group in a faucial growth renders it at least possible that the internal maxillary group is also affected.

Apart from these two groups, the lymphatic drainage of the mouth is comparable with that of the tongue. Carcinoma of the floor of the mouth, if situated anteriorly, may give bilateral metastasis, and direct involvement of the jugulo-omohyoid group is more than a theoretical possibility. On growths of the cheeks and upper lips spread is mainly downwards in the line of the facial vein, and involvement of the parotid group is not common. Carcinoma of the central part of the lower lip is likely to affect the submental glands, while growths in the lateral part usually miss the submental group and pass direct to the submaxillary region, or to the glands of the deep cervical chain.

OPERATIONS FOR NON-MALIGNANT CONDITIONS OF THE MOUTH AND TONGUE

Congenital and Developmental Abnormalities

Hare lip and cleft palate.—These conditions are dealt with on p. 1607.

Macroglossia.—True macroglossia, as opposed to the much commoner lymphangiomatous enlargement, is usually found in mentally deficient children. Treatment may be required if the tongue is large enough to make feeding difficult, and the best operation is excision of a wedge of the whole thickness of the tongue, including the tip. The operation presents no special difficulties, but children suffering from this condition tolerate operative interference badly and may actually die as a result. The most important matter is the arrest of hæmorrhage. Vessels that can be seen must be caught before division and ligature. Bleeding from smaller vessels and oozing is arrested by careful approximation with sutures passed through the whole thickness of the tongue.

Abnormalities of the frænum.—Tongue tie, or undue shortening of the frænum, although rare, is occasionally met. The operation of division of the frænum was at one time frequently performed on the slightest indication. It is not free from danger, and many fatalities are on record, both from hæmorrhage and from suffocation due to dropping back of the tongue. Division of the frænum should not be practised in newly-born children. If performed later, it is safe and perfectly simple, but the tongue should not be stripped up from the floor of the mouth, and an attempt should be made to secure primary union of the mucous membrane, otherwise the resultant scarring is apt to leave the patient in a worse position than before. Bleeding is the great risk and any spouting vessel must be caught and tied.

Sublingual dermoids.—These tumours may reach a large size before the patient seeks advice. They are best approached by an external incision between the mandible and the hyoid bone. If the cyst is small, a midline incision is adequate, but for large tumours it should be transverse. The mylohyoid is divided in the line of the incision, and the cyst exposed. There is sometimes a fibrous attachment to the jaw or the hyoid bone but, apart from this, there is no difficulty in completing the removal by blunt dissection. If the wall of the cyst is accidentally ruptured, the operator must make sure that the whole of the epithelial lining is removed, as otherwise a sinus will persist and necessitate a second operation. It is often difficult to dissect out the larger cysts entire but if they are torn it is a good plan to put a finger inside to act as a guide to their deep connections. Removal of a sinus, whether it results from spontaneous infection or, as it more commonly does, from inadequate surgical treatment, is much more difficult. The operation consists in complete removal of the track from among the muscles of the floor of the mouth. Provided that no part of the epithelium or granulation tissue lining the track is left behind, this operation gives good results, but it is tedious, and difficult to perform owing to the inaccessibility of the region and the vascularity of the surrounding tissues.

Ranulæ.—These tumours appear to be situated superficially under the mucous membrane to one side of the frænum of the tongue, but actually they spread deeply and irregularly among the muscles, between the jaw and the hyoid. Attempts to remove them completely are seldom successful, and it is generally better for the operator to satisfy himself with the following procedure. The cyst is opened, and the sticky mucous secretion which it contains is thoroughly removed. This is best done by entangling the mucus in pledglets of dry gauze held in forceps. The wall is then scrubbed with a small mop soaked in pure carbolic acid, to destroy the epithelial lining, and the resulting cavity is temporarily packed with gauze which may be fixed in position by a few catgut sutures. The results of this operation are very satisfactory, and the more elaborate methods which have been recommended to ensure complete excision of the wall are unnecessary.

Thyroid rests at the base of the tongue.—Ulceration with profuse hæmorrhage is the usual indication for removal of these tumours, and the operation is not easy. Removal through the mouth, after drawing out the tongue as far as possible, is the correct procedure in most cases, but although the tumours are encapsulated, they are extremely vascular, and the operator must be prepared for violent hæmorrhage. Preliminary laryngotomy or tracheotomy is worth considering, as it enables the operator to proceed at leisure with the pharynx packed off from the mouth. Hæmorrhage may be limited to some extent by using diathermy excision instead of the knife. Trotter's method of splitting the tongue from before backwards in the middle line may be useful for large tumours. This method is described on p. 1562.

Acute Inflammatory Conditions

Lingual abscess.—This may be a complication of a retained foreign body or occasionally a sequel of acute superficial glossitis. It is best opened by a longitudinal incision and, if the tongue is greatly swollen, a preliminary tracheotomy should be done under local anæsthesia. Through this tracheotomy general anæsthesia can be administered and the pharynx packed, in order to prevent aspiration of pus into the respiratory passages. If the abscess is in the front of the tongue the patient can be anæsthetized in the ordinary way. With the patient on the side and the back of the mouth packed lightly with gauze, there is little risk during the short period which will be necessary for incision and evacuation of the pus.

Ludwig's angina.—The operative treatment is to evacuate the pus as soon as it can be diagnosed. The disease appears to originate as a cellulitis in the tissues deep to the mylohyoid. External signs of softening are late in appearing but, if incisions are made into the brawny swelling beneath the jaw a day or two after the onset of the disease, it is usually possible to discover and evacuate an abscess cavity. A full general anæsthetic is necessary, and the first incision should run from the hyoid to the point of the jaw, keeping strictly to the mid-line so as to avoid excessive hæmorrhage. The incision is then deepened through the mylohyoid and, if pus is not discovered at once, a pair of blunt forceps should be passed deep to the mylohyoid in the direction of the molar teeth on one or other side. Once the abscess cavity has been discovered, counter-incisions may be made. This disease is apt to occur in debilitated patients, and in them the mortality is high.

Cancrum oris.—This disease is fortunately rare under present-day conditions. Conservative treatment usually fails and the best chance of saving the patient's life is to excise the gangrenous area without regard to subsequent deformity. Excision by diathermy is preferable and the incision should be made beyond the area in which the vessels are thrombosed. Some necrosis of the jaw may be expected. A long interval must be allowed before any attempt is made to close the resulting defect, and during this time the patient should be taught to use a wooden wedge between the teeth to prevent trismus.

Chronic Inflammatory Conditions

Leukoplakia and chronic superficial glossitis.—Patches of thickened epithelium on the lips are occasionally encountered in elderly men, some of whom have already suffered from an epithelioma in another part of the lip, and these lesions are probably a pre-carcinomatous change. Their disappearance can often be secured by superficial irradiation with unscreened radium, a treatment which lasts only a few hours and does not necessitate confinement to bed. Lesions which resist this treatment can sometimes be cured by a very small dose of interstitial irradiation. Local excision is less satisfactory, as the change is apt to recur in the neighbourhood of the scar.

Chronic superficial glossitis and leukoplakia in the tongue.—Localized patches of diseased epithelium may be excised for biopsy. Such incisions are best performed with the diathermy knife, as primary union is difficult to secure in any case, and the scar left by diathermy is softer and more pliable than that which results from a knife excision in which healing has taken place by granulation.

Berven * states that the dose of irradiation necessary for the cure of leukoplakia is so large that there is a danger of damaging normal tissues. The condition is now treated at Radiumhemmet** by the internal administration of magnesium sulphate (1 gm. three times a day) and, if necessary, by diathermy coagulation to the depth of a few millimetres. Healing may be expected in about one month and the scar which results from this treatment is soft and supple.

Ulcers of the Tongue and Mouth

Excision of ulcers in the tongue is best performed with adequate general or regional anæsthesia. Local anæsthetics are less suitable, as the œdema which they produce makes it more difficult for the operator to be certain of the limits of the disease. The tongue should be drawn out and exposed by several tractor stitches, so that the ulcer and the surrounding tissues are fully exposed. Diathermy is convenient, as it reduces the amount of bleeding and may, in tuberculous ulcers, reduce the likelihood of re-infection of the wound, but it is open to the objection that a large proportion of diathermy wounds fail to heal by first intention.

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* *Acta. Rad.*, 1929, x, 3.

** The Radium Institute in Stockholm.

Simple or traumatic ulcers.—Ulcers which are thought to belong to this class should always be excised if they fail to react to conservative treatment within a week or two. Since biopsy is the main object of the excision, it must extend widely enough into the surrounding normal tissue to ensure a satisfactory microscopic section (see p. 1556). Carcinomatous ulcers of the lower alveolus may present none of the ordinary physical signs of malignancy, and early biopsy in this situation is of special importance.

Tuberculous ulcers.—Tuberculous ulcers of the tongue complicating advanced pulmonary disease are generally regarded as unsuitable for surgical treatment, though Butlin stated that, if they are not very extensive, they " may be removed to the great relief of the patient." Tuberculous infection of the resulting wound is difficult to avoid, and if it occurs the patient is undoubtedly worse off for his treatment. When ulcers are multiple, operative removal should never be attempted.

Tuberculosis of the tongue occasionally occurs as an isolated manifestation, and in this case excision is the correct treatment, but must be wide if it is to be successful, and in fissured ulcers, which are often very much deeper than they appear to casual observation, the operator must take particular care that his excision of the deeper parts of the ulcer is complete.

INNOCENT TUMOURS

Papillomata.—These should always be removed and, unless they are very obviously innocent, a wedge of the underlying muscle should be taken so that the absence of infiltration can be demonstrated microscopically. Radium has no very marked advantage over excision, and has the disadvantage that it does not afford the opportunity for biopsy.

Cavernous nævi in the mouth, as elsewhere, consist of varying proportions of fat and vessels. When they attain a large size they are very troublesome to deal with, and if they are seen when small they should not be neglected. Excision is the most satisfactory operation, and, if the incision be made a little wide of the tumour, there is seldom any real difficulty in controlling the hæmorrhage.

Similar lesions on the lip are more difficult, as they are frequently large enough for simple excision to produce noticeable deformity. Ligature of the labial arteries is useless, as the tumour very rapidly attains a fresh blood supply, and any diminution in its size is rapidly made up. Irradiation is often successful to some extent, especially in young people. Very small doses should be used (about 60 mgm. hours per cubic centimetre of tissue by the interstitial method) and it must be remembered that the tumour may continue to diminish in size for months or even years after the completion of the treatment. Second irradiations may be necessary, but should not be given within six months of the first.

Lymphangiomata occur in the tongue and lip. They do not appear as localized tumours, but rather as a diffuse enlargement of part or whole of the organ, and they are usually associated with some degree of vascular dilatation. They grow slowly but certainly, and should therefore be treated as soon as the opportunity arises. Excision of the affected part of the tongue is the ideal treatment. When this can be done through healthy tissue the results are satisfactory, but if, as may well happen, the excision is incomplete, recurrence is likely. Hæmorrhage during the operation is apt to be considerable, but much of it is capillary, and may be controlled by suturing, without picking up individual vessels.

Treatment of lymphangiomata by radium is a matter on which it is difficult to speak with certainty. Cure is unlikely, but interstitial irradiation does appear in some cases to make the tumour smaller and harder and to reduce the liability to recurrent hæmorrhages which are sometimes a serious feature. Whether the improvement is due to the specific action of the radium, or to the inflammatory reaction caused by the introduction of the needles, is impossible to say, but in cases which are unsuitable for radical excision, interstitial irradiation on the lines recommended for hæmangiomata should be tried. Doses of this magnitude do not produce any deleterious effects in the normal tissues, and do not interfere materially with their reaction to trauma if excision subsequently becomes necessary.

Lymphangiomata are subject to recurrent attacks of inflammation during which their apparent extent is much increased. Treatment should never be attempted during these attacks, as the inflammation always subsides spontaneously and the tumour rapidly shrinks to its former dimensions.

Mixed tumours.—Tumours having the structure and physical signs of the ordinary salivary tumour are sometimes found on the palate or the inner surface of the lips and cheek. They are usually very easily shelled out, and do not normally tend to recur, but occasionally, in children, mixed tumours of doubtful origin recur, or even metastasize.

MALIGNANT DISEASE OF THE MOUTH AND TONGUE

The growths in this group differ greatly from one another in their clinical characteristics, their reaction to treatment, and their ultimate prognosis. It is therefore impossible to treat them as a single class, and it has been thought better to consider, first, general principles, and the available means of treatment, and secondly, their application to growths in various sites. It must be remembered that treatment must be varied, not only according to the type and anatomical situation of the growth, but also according to its stage. Surgical treatment in carcinoma of the mouth at the present day is not concerned solely with the eradiction of the disease in operable cases. There are many cases in which the ultimate prognosis is so nearly hopeless that an attempt at radical removal by operation or irradiation exposes the patient to suffering which is quite disproportionate to his chance of cure. Many of these cases can now be made comparatively comfortable for periods up to several years by palliative measures, and the possibilities in this direction are reflected in the increasing proportion of cases which are considered suitable for treatment. It is therefore essential for the surgeon to have in his mind at the outset a clear idea of the stage of the growth he is about to treat, as well as the degree and type of its extensions and something of the probable outlook. If he neglects this precaution he is likely to become involved in an operation or irradiation which starts as a radical treatment and finishes as a palliative one. The results of such procedures are disastrous, and they should be remembered by the surgeon who is tempted to throw aside all other considerations in his attempt to extirpate the growth. It may happen thus that the interests of the patient are best served by extending the field of treatment in early cases, and contracting it in extensive ones.

GENERAL PRINCIPLES OF TREATMENT

The ideal treatment for carcinoma in the mouth, as elsewhere, is an operation of the type of the Halsted excision of the breast ; that is to say, removal in one block of the primary growth, with a wide margin of apparently normal tissue, the lymphatic areas concerned and the intervening tissues. If this were possible, the surgeon could approach his early cases of carcinoma in the mouth with the same degree of confidence as he can those in the breast. Unfortunately, such an operation is impossible in the mouth. The margin of normal tissue which can be removed without encroaching on essential structures is extremely small, and excision of the primary growth and the affected glands in continuity throws open the planes of the neck to infection from the mouth and frequently leads to severe or fatal sepsis.

To a certain extent these difficulties may be overcome by the use of irradiation in the place of operation, as essential structures which cannot be removed can mostly be irradiated sufficiently to destroy carcinoma cells which are present, and irradiation can be made continuous from the primary growth to the limit of the metastases. For these reasons, surgeons who are familiar with both methods will be better advised to make use of irradiation where the primary lesion cannot be clearly separated from the secondary glands. Such growths occur fairly often on the lateral side of the tongue and sometimes in the floor of the mouth. This is not to suggest that operations for this type of growth should be entirely abandoned. There are cases in which such operations have been done and the patient has remained free from recurrence for many years. They do, however, carry a high mortality as a result of shock, sepsis and pulmonary complications, with the additional disadvantage that, if the operation fails to eradicate the disease, recurrence is likely to take place in the wound, leaving the patient worse off than before.

If there is no evidence of direct continuity between the primary growth and the glandular areas, the advantages of radium are less obvious, and most surgeons at the present time prefer to regard the treatment of the primary growth and that of the glandular areas as two separate problems. Although this is unsatisfactory in theory, experience has proved that recurrence, when it does take place, is nearly always in the site of the primary growth, or in the glandular areas, and only exceptionally in the intervening tissues.

The principles of treatment applicable to all growths in the mouth may be summarized as follows :—

(1) **If the primary growth affects soft parts only and its situation allows excision with a margin of one-third of an inch or more of apparently normal tissue,** it matters little whether irradiation or excision be used in its treatment. Irradiation in the hands of a surgeon who has been trained in its use has the advantage that the primary mortality is negligible, and the ultimate deformity slight.

(2) **If the primary growth is inoperable or doubtfully operable,** irradiation is the correct treatment. If the difficulties of operation are due to inaccessibility, distant irradiation by the "radium bomb," or deep X-rays, is generally preferable.

(3) **Certain cases in which the primary growth is known to be highly radiosensitive,** such as lympho-epithelioma of the posterior third of the tongue, should always be treated by irradiation in whatever stage of their development they are seen. These growths infiltrate the tongue widely, and are most unsuitable for operation, whereas irradiation generally secures their rapid disappearance.

(4) **When infected* glands are present and they cannot be clearly separated from the primary growth,** treatment by irradiation is capable of producing good palliative results. Operation carries a high mortality, but produces occasional cure. Infected glands which are not in direct continuity with the primary growth should be treated separately.

(5) **Growths which infiltrate compact bone** such as the lower jaw are unsuitable for irradiation. Excision is nearly always worth trying and sometimes gives very good results.

TECHNIQUE OF IRRADIATION

Irradiation is destructive to all tissues, and its use in the treatment of malignant disease depends on the attainment of conditions in which the injury inflicted on the normal tissues is capable of repair, while that inflicted on the growth is not. These conditions are not so easy of attainment or the advantage of the method so overwhelming as to have rendered operation obsolete, and the surgeon who has had no special experience in the use of radium, and who finds himself compelled to treat carcinoma of the mouth, is better advised to retain operative methods rather than to attempt the use of radium if he is hampered by insufficient experience.

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* *i.e.* Glands invaded by new growth

Irradiation used in the treatment of carcinoma of the mouth may be applied from a near or a distant source external to the growth, or directly by inserting needles into the affected tissues. The technique of the last two methods is described elsewhere as surface and tele-irradiation.

Interstitial irradiation is more within the province of the surgeon. It is applicable to most malignant lesions in the mouth, though it is probably inferior to distant irradiation in the treatment of glandular metastases. It must be emphasized that interstitial irradiation is a method which is capable of doing a great deal of harm unless the principles of its use are fully understood.

Radium needles of many sorts are available, but by no means all of them are suitable for the treatment of carcinoma of the mouth. The chief concern of the surgeon is to obtain needles of such lengths as will enable him to irradiate the tumour uniformly and which contain radium in quantities which make it possible to deliver the desired dose by leaving them in position for 7 or 8 days. The type of needle which best conforms to these requirements is one which contains about 0·75 mgm. of radium to each centimetre of its active length. A needle of this type is spoken of as having a linear intensity of 0·75 and, provided that it is adequately screened and the radium in it is uniformly distributed, it can be left in position 7-10 days without fear of causing necrosis.

This technique is not universally used. Radiumhemmet, for instance, employs needles containing 10 mgm. of radium per centimetre of length, and leaves them in position for 3–4 hours, but where the technique of irradiation of special growths is described in the ensuing section it is assumed that needles of approximately 0·75 linear intensity are in use.

Certain special instruments are necessary for the insertion of radium needles in the mouth. Needles may be inserted through the skin, after puncturing it with a tenotome, and retained in place by means of a tiny piece of gauze soaked in mastic solution, or alternatively through the mucous membrane. In the latter case they should be retained in place by a stitch inserted in the manner shown in Fig. 724. If this stitch is tied sufficiently tightly it will cut out before removal of the needle is due.

Estimation of the correct dose.—If the technique of prolonged exposure is adopted, and radium is left in contact with the tissues for 7–9 days, the correct dosage is about ¾ of a milligramme of radium for each cubic centimetre of tissue which contains, or is suspected of containing, carcinoma cells. Accuracy in dosage is very important and can only be attained by considering each case individually.

The surgeon should examine the case which he is proposing to treat by irradiation with as much regard for detail as if he were about to attempt a radical excision. Before embarking on the treatment he must have in his mind an exact picture of the size and shape of the block of tissue which he proposes to irradiate, that is to say, of the growth itself, together with the tissue into which it probably extends. Accuracy is not easy, but is greatly helped by a measuring calliper. By the aid of the mental picture thus constructed, the surgeon plans a method of insertion of needles which will produce as nearly as possible a uniform irradiation of this block of tissue. The actual arrangement of needles which is necessary to give a uniform irradiation is a matter on which we are not at present very well informed, but it appears from clinical experience that, using needles of the type recommended above, the surgeon may regard each needle as exercising its influence over a cylindrical piece of tissue 1 cm. in diameter, and corresponding in length to the active length of the needle. If he arranges his needles so that these spheres of influence are in contact over the whole of the area to be treated, he will attain a degree of uniformity sufficient for his purpose.

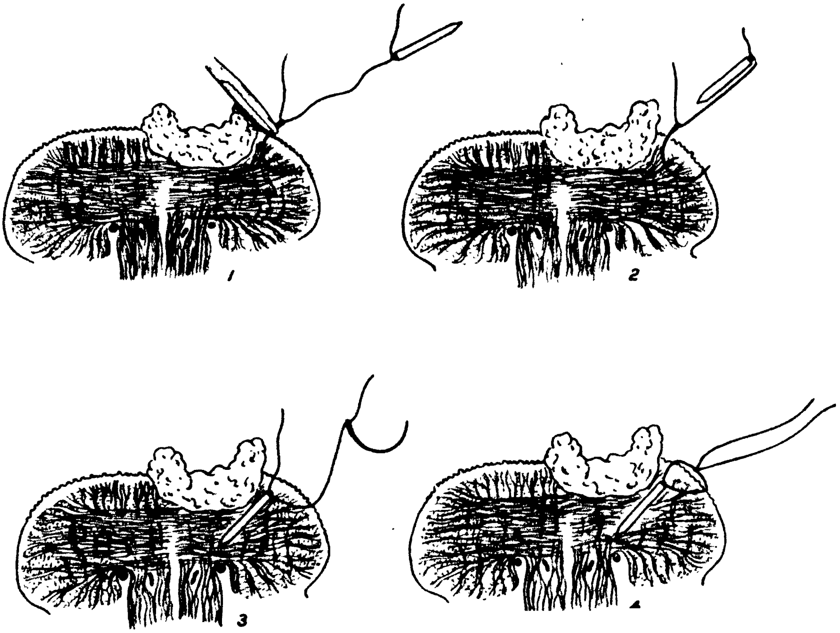

Fig. 724.—Method of insertion and fixation of radium needles in the tongue.

Fig. 725 suggests how this principle may be applied to a simple case in which it is desired to irradiate a carcinoma of the lip, together with its extensions to an enlarged submaxillary lymph gland.

The surgeon must always remember that the two most serious errors which he can commit are overdosage and irregular dosage. There is a natural tendency, which is surprisingly difficult to overcome, towards the use of larger doses in advanced growths. It cannot be too strongly emphasized that an increase of the dose beyond the ordinary limits in these circumstances does not produce an increased effect on the cells of the growth and, moreover, defeats the object with which it is used by damaging the cells of the normal tissues. Thus, as Berven says,* " Overdosage gives rise to necrosis with rapid growth of the tumour.". Irregular dosage is an even more serious error, for it leads to the persistence of areas of inadequately treated growth in the midst of necrosed normal tissues. A patient who has suffered as a result of this error is left in a pitiable condition, with growth uncured in the midst of tissues which have been so badly damaged that they are incapable of resisting any further trauma. Such patients are still occasionally seen, and their condition is far worse than that of untreated cases.

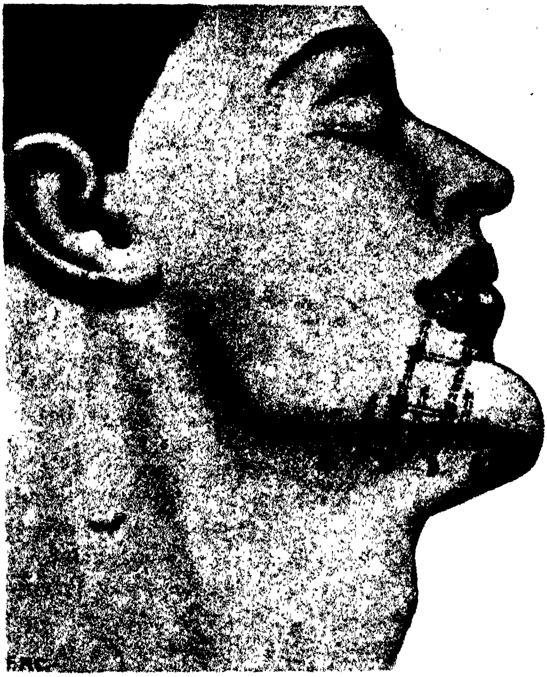

Fig. 725.—Insertion of radium needles for cancer of lip.

The total dose.—It does not generally happen in the mouth or tongue that the total dose of irradiation is sufficient to give rise to severe general symptoms. Most patients, even if their physical condition is poor, will stand a dose of 3,000 to 5,000 mgm.-hours spread over 7 or 8 days, without suffering anything more than a mild general malaise, though there is a certain amount of individual variation. Nevertheless, the surgeon should always work out the total dose in milligramme-hours which would be given by the plan he has made, and, if he finds it excessive, the plan must be altered. When it is necessary for this reason to reduce the dose applied to the growth, it is better to thin out the needles in the centre of the growth while adhering to the original plan at the periphery.

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* *Acta Rad.* 1937, xviii, 16.

Diathermy.—By diathermy, growth may either be coagulated *en masse*, or separated from its surroundings by using the diathermy point as a knife. The latter method has certain advantages over ordinary excision. Firstly, there is much less bleeding at the time of operation, and it is consequently much easier for the surgeon to see the exact relation between the borders of the growth and the limits of his excision. Secondly, there is some evidence that heat exercises a selective influence on the cells of malignant neoplasms, and that these cells are destroyed by endothermy in an area wider than that in which the normal tissues are damaged. (Kristian Overgraad.) Thirdly, it is supposed that the sealing of the lymphatics which take place when tissues are divided by diathermy is to some extent a protection against the development of metastases. In the post-operative period patients who have been treated by diathermy show remarkably little general disturbance. Pain is usually slight, and after the sloughs have separated the resultant scar is soft and pliable.

There are, however, certain disadvantages. It is almost impossible to avoid sparking in the tissues, and therefore inflammable anæsthetics such as ether cannot be used. A certain amount of sloughing in the region of the wound is inevitable, so that primary union after diathermy excision is very difficult to obtain, and secondary hæmorrhage may occur during the separation of the sloughs. Perhaps the most serious drawback to the use of diathermy in the mouth is the likelihood of causing necrosis of bone, particularly when it is employed after radium treatment. If the bone involved is the lower jaw, sequestra may take six months or longer to separate. This process is often attended with severe pain and the effect on the general condition of the patient is sometimes very serious.

Diathermy coagulation is not much used in this country, but it is part of the regular technique at Radiumhemmet, where it is used as a primary treatment and also to destroy the site of a previously irradiated growth.

Diathermy excision is probably rather less efficient than coagulation in securing destruction of malignant cells beyond the obvious limits of the treated area, but the resulting wound is clean within 12 days of operation, and, if necrosis of bone takes place, it is not generally extensive.

PRE-OPERATIVE TREATMENT IN CARCINOMA OF THE MOUTH

Extensive operations and irradiations in the buccal cavity throw a very considerable strain on the general health of the patient, and the ability to resist infection and to restore damaged tissues to normal is a factor of great importance in recovery. In all cases time must be found for a certain amount of preliminary treatment, both general and local, before the major interference is undertaken, and it is surprising to see how often this appears to exert a beneficial effect on the growth itself.

General treatment consists mainly in good nursing and good food ; for many patients, especially of the hospital class, are quite exhausted by pain and semi-starvation when they apply for treatment. Most of them improve greatly under proper nursing care, but it is impossible to build up a patient who cannot ingest an adequate amount of nourishment and, if swallowing is very painful and difficult, there is every justification for temporary gastrostomy. This operation may be easily done under local anæsthesia, and as soon as the artificial opening is functioning satisfactorily the patient begins to gain ground. Patients who have had gastrostomy performed are not only more easily fed, but also suffer less from pain and excessive salivation.

Preliminary tracheotomy must also be considered. A patient who has a foul ulcer runs a considerable risk of developing pulmonary complications when this ulcer is interfered with, whether by operation or irradiation. The immediate effect of irradiation may also be to increase the size of the mass by producing œdema round it, and, if the growth is near the upper opening of the larynx, this may induce dyspnœa where it did not exist before. Tracheotomy done at leisure under local anæsthesia is an easy and satisfactory operation, whereas if it is done as an emergency in a patient already suffering from severe dyspnœa it is both difficult and dangerous. Therefore, if tracheotomy is likely to be required during the course of the treatment, it should be done as a preliminary, and separated from the major treatment by a fortnight or even more. In my opinion this is infinitely superior even to a temporary tracheotomy or laryngotomy done immediately before operation. One good reason for the comparatively long interval is that most patients who require tracheotomy for carcinoma of the mouth develop some degree of bronchitis as a result of the tracheotomy alone. If the pulmonary morbidity of the major operation is superimposed on this, the chances of broncho-pneumonia become extremely high, whereas if the original bronchitis is allowed to subside completely it is often possible to anæsthetize the patient a few weeks later through the tracheotomy without provoking any exacerbation. A second good reason is that, like gastrostomy, tracheotomy relieves the patient of distressing symptoms, and so contributes to general well-being.

An important point in the technique of tracheotomy is the opening of the trachea and the removal of a disc from its wall instead of the usual longitudinal incision. This does not delay healing and it makes the changing of the tube at any time easy and completely safe. St. Clair Thomson's modification of Durham's tube is the only satisfactory one.

If it is decided that gastrostomy and tracheotomy are unnecessary the patient must be instructed in methods of feeding which do not involve the active propulsion of food from the mouth to the pharynx, as this act is generally impossible for a time after operation or irradiation. A nasal tube may be employed, but a better method is the use of a feeding cup with a rubber tube attached to the spout so that the patient can deliver fluids straight into the pharynx. A little practice in the use of this apparatus before operation greatly reduces the troubles of the immediate post-operative period.

Dental treatment.—No major buccal operation should be attempted when gross dental infection is present. Extraction of septic teeth diminishes the risk of post-operative sepsis and respiratory complications and also contributes to the well-being of the patient by reducing salivation and discomfort. In some circumstances the direct effect on the primary lesion is very marked, and a growth which has appeared inoperable by reason of its size and fixity may be found to be clearly operable after sepsis has been reduced by removal of infected teeth.

The practice of removing all teeth, whether septic or not, is unjustifiably drastic. Dental extraction is a major operation which is not free from risk in elderly patients, particularly when the teeth are firmly fixed, and it is better to insist on extraction of only those teeth which are grossly infected, and to advise conservative treatment for the rest. The gums must be allowed to heal completely before any further operative treatment is undertaken, and to ensure healing in the shortest possible time great care must be taken not to inflict unnecessary damage on the alveolus by rough manipulation during extraction.

Radium treatment is said to be less effective in the cure of carcinoma and to be more likely to cause necrosis of the jaw if infected teeth are present. In addition, metal bridges and fillings are an important cause of secondary irradiation at the time of treatment, and for many years after treatment the susceptibility of an irradiated jaw to trauma is so greatly enhanced that even a simple extraction may produce widespread necrosis. For these reasons, teeth which are heavily stopped, and those which are likely to give trouble in the near future, should be removed before treatment by irradiation is begun. Other teeth may be scaled and metal-work removed, but sound teeth should not be disturbed.

Preliminary treatment with sulphonamides.—It is still uncertain whether routine use of sulphonamide before operation has a significant effect in reducing post-operative complications. It is reasonable to suppose that both spreading wound infection and broncho-pneumonia are less likely to develop if a high concentration of sulphonamide is present in the blood at the time of operation, and I have recently adopted the practice of giving a course of sulphonamide therapy in the 48 hours preceding operation. Sulphathiazol is probably the most satisfactory preparation.

Biopsy.—Biopsy should be done when there is any doubt of the diagnosis. In other cases, even when diagnosis is certain, microscopic structure gives valuable indications of the most appropriate form of treatment. The tissue removed must include a part of the growing edge of the tumour and must be of a size and shape which enables the pathologist to be certain of cutting the section at right angles to the surface. Preliminary teleradiation is sometimes used to reduce the risks of metastasis when the growth is cut into.

Preliminary control of hæmorrhage.—Trotter stated that he had never done an operation for preliminary control of hæmorrhage from the mouth or jaws and had never regretted the omission. In the few cases in which preliminary control of hæmorrhage is necessary it is best to perform the gland dissection first and to tie the external carotid or its branches during the course of this operation. The formal operation for ligature of the external carotid is described at p. 505, Vol. I.

ANÆSTHESIA IN OPERATIONS FOR MALIGNANT DISEASE

Operations on the anterior part of the tongue and the floor of the mouth can be satisfactorily performed under a combination of local and regional anæsthesia after blocking the lingual and inferior alveolar nerves by Braun's method. Simple local anæsthesia is adequate for the lip and cheek.

Local anæsthetics reduce hæmorrhage from small vessels, and make operative technique easier. It is claimed that they also reduce the incidence of chest complications. This is probably true, but it must be remembered that inhalation of anæsthetic vapours is certainly not the only cause of chest complications, and probably not the main one, so this point should not weigh too heavily in the choice. The majority of patients in this country are not very receptive to the idea of local analgesia, and it often has to be supplemented with some form of basal or inhalation narcosis, so that, as regards toxicity, there is often little to choose between this and an ordinary general anæsthetic. Moreover, local anæsthetics are not very suitable for cases requiring interstitial irradiation, as the œdema which results from the injection obscures the outlines of the growth and makes it difficult to be sure of inserting the needles accurately.

Basal anæsthetics are pleasant for the patient, but have the disadvantage that they depress respiratory activity in the post-operative period. Probably the most satisfactory combination is preliminary intravenous injection of 3–4 c.c. of sodium evipan followed by gas oxygen and ether, administered either by the nasal intra-tracheal route or through a tracheotomy, so that the surgeon can plug off the pharynx completely from the mouth.

The only serious disadvantage of the nitrous-oxide-ether method is the impossibility of using it with diathermy. Sparking in diathermy operations can never be entirely eliminated, and there is a very serious risk of explosion if it is allowed to occur in the neighbourhood of ether vapour. It is generally considered to be safe to induce anæsthesia with ether in these cases, and to change over to chloroform a few minutes before the diathermy apparatus is brought into use. This method is very commonly employed, and no accidents have been recorded, but it is doubtful whether it is absolutely safe.

Trotter stated that if a tracheotomy is to be done chloroform is the only anæsthetic. Given through a tracheal opening it has proved, in a very large experience, to be entirely safe. The only danger is during the period of induction before opening the trachea. Such danger can be minimized by beginning the induction with the patient on the table and the surgeon ready to operate ; it can be avoided entirely by a preliminary tracheotomy under local anæsthesia. In patients with an ulcerating growth and salivation the least sniff of ether should be forbidden. Given through a tracheotomy opening with a plugged pharynx, chloroform is rarely followed by vomiting.

METHODS OF EXPOSURE

These methods are grouped together, as any one of them may be used for the exposure of growths in several situations. They may be used as the preliminary stage of an operation or, occasionally, to expose a growth for interstitial irradiation. In the latter case the irradiated area must be completely separated from the tissues involved in the operative exposure, as a combination of operation and irradiation in the same wound always leads to delayed healing.

1. **Horizontal splitting of the cheek.**—This is a very useful method of exposing growths which lie far back on the side of the tongue or on the posterior part of either alveolus, and has the great advantage that it does not open up the tissue planes of the neck to infection from the mouth. The whole thickness of the cheek is divided from the angle of the mouth to the anterior edge of the masseter, the incision being kept below the line of the parotid duct. (Fig. 726.) Bleeding is fairly free, but it is easily controlled by ordinary methods, and diathermy should not be used, as it jeopardizes the chances of primary union. Primary union of the cheek, after division by the knife, can generally be obtained if the wound is protected during the operation. As soon as the incision is made and the larger vessels ligatured, a fine continuous stitch is used to bring mucous membrane and skin in close contact over the raw surface throughout the wound. This temporary stitching-over not only prevents contamination but checks oozing. At the end of the oral part of the operation the continuous stitch is removed and the cheek united.

The mucous membrane must be carefully and accurately sutured in all cases. If infection is likely, it is better not to suture the skin, but to use one or two tension stitches which draw together the whole thickness of the cheek, and are tied over small pieces of rubber tubing. The skin wound may be left completely unsutured, and covered with a piece of gauze fixed by mastic solution. This method gives good results and a scar produced by mattress sutures used in this manner does not ultimately become depressed below the surface of the surrounding skin.

By extending this incision further back across the edge of the masseter, and raising the muscle and the parotid gland, the greater part of the ascending ramus of the jaw can be exposed.

If the incision is kept in the line of the gap between the upper and lower alveoli, and is not extended more than a centimetre or so behind the edge of the parotid gland, any facial paralysis is very unlikely, and by using the incision in this way extensive growths which affect the posterior part of the alveolus can be adequately exposed and removed without undue difficulty.

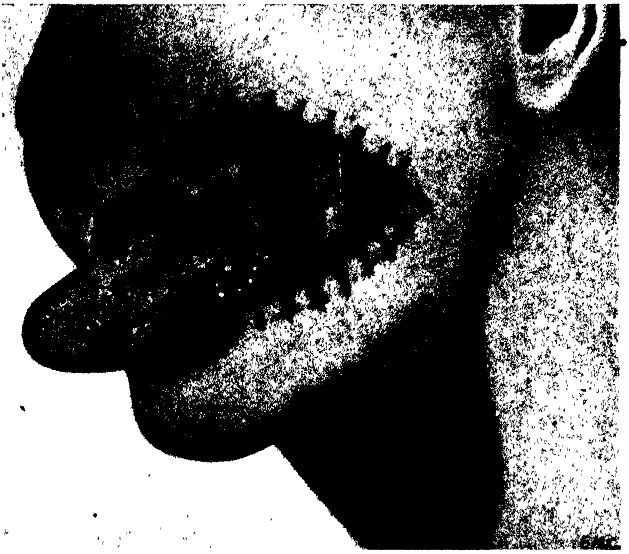

Fig. 726.—Side of tongue and fauces exposed by horizontal division of cheek. The skin and mucous membrane along the edges of the incision have been temporarily united by a continuous stitch to prevent infection.

2. **Division of the lower jaw in the middle line. Syme's method.**—This gives an excellent exposure of localized growths in the floor of the mouth, but when the mouth is free from gingivitis and the lateral border of the tongue is to be exposed, it is better to divide the jaw to one side of the mid-line, without freeing the soft tissues behind it. The operation for median division begins with the extraction of the two central incisor teeth. An incision is then made from the middle of the lower lip to the hyoid bone, keeping accurately to the middle line. The whole thickness of the lip and the soft tissues overlying the chin are divided, but from the point of the chin to the hyoid bone only the skin, the subcutaneous tissue, and the platysma are included in the primary incision, so that the fatty tissue of the submental triangle, which may contain lymphatics infiltrated with growth, is left undisturbed. The insertions of the mylohyoids and the geniohyoids are separated from the posterior surface of the jaw for about half an inch

on either side of the mid-line, and the mucous membrane is carefully separated from the posterior surface of the alveolus. A copper spatula is then introduced as close as possible to the bone, so as to protect the soft tissues behind it. It is convenient at this point to drill the holes, in the bone on either side of the mid-line, which may be required to admit a silver wire to unite the two halves of the jaw when the operation is concluded. If the saw-cut in the jaw is made slightly angular, wiring is often not necessary and sufficient apposition is obtained by stout catgut stitches through the tissues close to the bone.

A saw is used to divide the jaw between the holes, as the crushing and splintering which may be produced by bone-cutting forceps predisposes to sequestration. If the growth is attached to the bone, the jaw may be split between the inner and outer tables, or divided on either side of the growth so as to remove a portion of its whole thickness. The flaps below the jaw are turned aside far enough to allow the submental region to be cleared of its fatty tissue and glands, but the operation should not be carried farther than this into the tissue planes of the neck. The mylohyoid is now divided, and the two halves of the jaw drawn gradually (and, if necessary, widely) apart to expose the tissues of the floor of the mouth. The further steps of the operation depend on the nature and extent of the primary lesion, and those suitable for dealing with a sublingual growth are detailed on p. 1572.

In the subsequent repair an attempt must be made to provide an adequate covering of mucous membrane in the floor of the mouth. As a rule, the two halves of the jaw are united by silver wire, the ends of which may be left long for removal later. The skin edges are drawn loosely together, leaving ample space for drainage.

If this operation is carefully carried out in suitable cases, it gives an excellent exposure, without involving much risk of infection in the tissue planes of the neck. The wire has often to be removed subsequently, and small sequestra may form at the site of division of the jaw, but failure of union and massive sequestration are both very rare, so that at the worst the patient has only a small sinus until the wire or the sequestra are removed. Modifications of this operation may be devised to suit extensive growths which have infiltrated the bone, but it should never be attempted if the region has previously received a full dose of irradiation. The impairment of nutrition which follows such treatment entirely changes the reaction of the tissues to trauma, and if the operation described above is performed after irradiation it may easily involve the patient in the miseries of an external salivary fistula and massive necrosis of the jaw.

Kocher, after abandoning his lateral submandibular operation, used a similar operation for practically all extensive growths of the tongue. He did not separate the soft parts and the periosteum from the jaw, and the bone was divided a little to one side of the mid-line so that the insertions of the genioglossi and geniohyoids remained intact on the sound side. The tissues of the floor of the mouth were then divided in a line determined by the position of the growth, and the tongue drawn over to the sound side as the two halves of the jaw were separated. (Fig. 727.) This method gives a very fair exposure of the side of the tongue, and, according to Kocher, the incidence of pulmonary complications is low because the mechanism of swallowing is preserved. It has the disadvantage of opening up the submaxillary triangle to infection from the mouth.

3. **Lateral division of the jaw.**—Langenbeck's original plan, which employs an L-shaped incision splitting the cheek and advancing downwards in front of the angle of the mandible, should never be used because it paralyses the lower lip. Far better is a median incision in the lip carried back below the jaw. In this way the lip, with its nerve supply intact, is turned back off the jaw until the place for dividing the bone is reached. The bone is divided obliquely so as to facilitate its subsequent reunion at the junction between the ascending and the horizontal ramus and, after division of the styloglossus and posterior belly of the digastric muscle, the mucous membrane is incised just in front of the palatoglossal arch. This operation gives an excellent exposure of the side of the tongue, and the oropharynx, but it is open to many objections. Pulmonary complications are frequent, and some degree of sepsis is inevitable, so that the primary mortality is high.

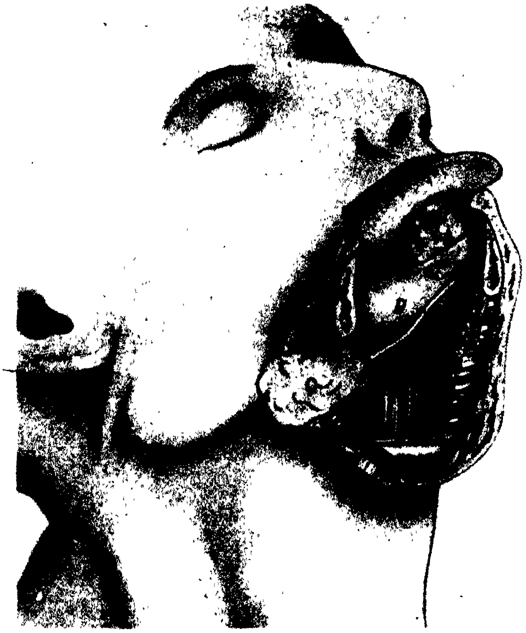

Fig. 727.—Exposure of sublingual growth by division of the jaw just to the right of the midline.

A, mylohyoid muscle ; B, digastric muscle ; C, submaxillary gland ; D, mucosa of floor of mouth. The lingual nerve has been removed. The insertions of the genioglossus and geniohyoids are left intact and the complete tongue is drawn over to the left.

External fistulæ may result, and in the jaw sequestration is common, with resulting non-union.

In certain cases where a carcinoma of the lateral border of the tongue has invaded the floor of the mouth and become attached to the jaw, an approach of this sort may be inevitable, and a few striking successes have resulted from its use, but it should not be used as a routine.

Trotter, who advocated the skin incision described above, recommended this operation combined with a lateral exposure of the pharynx for extensive growths which originate in the tonsillar region and involve the lateral pharyngeal wall. A vertical cut is made along the anterior border of the sterno-mastoid in addition to the original incision, which thus becomes Z-shaped, and, by turning back the flaps so marked out, the thyroid ala and the body and great cornu of the hyoid are exposed and resected. A limited gland dissection is done, the anterior branches of the external carotid are ligatured and divided, and the lingual, hypoglossal and superior laryngeal nerves are deliberately severed. The mandible is now divided between the horizontal and ascending rami and a complete lateral exposure of the pharynx is obtained.

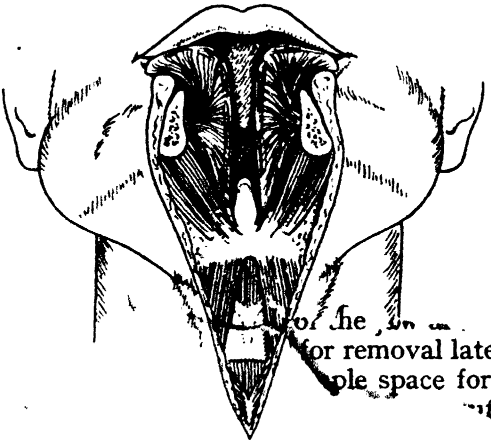

Fig. 728.—Exposure of hypoglottic region by Trotter's midline approach.

4. **Median division of the tongue.**—This method was advocated by Trotter for growths involving the base of the tongue. A preliminary tracheotomy is necessary, and the operation consists in a division of the jaw, the floor of the mouth and the tongue, in the middle line. The operation is described by Trotter in the following words :—" An exactly median incision is made over the lower lip, the chin and the submental region, to the top of the thyroid cartilage. The cut is deepened first below until the mylohyoid muscle has been divided, and then the interval between the geniohyoid muscles is found close to the hyoid bone. This interval is the best guide to the middle line, and it is opened up as far as the jaw. The incision is now carried through the lip down to the mandible, which is sawn through exactly in the middle line. The same line of cleavage is followed through the floor of the mouth to the tongue which is then split in the same way." (Fig. 728.)

Once the mucosa is divided, the greater part of the separation can be done by blunt dissection, the two halves of the jaw and the corresponding soft tissues being gradually drawn away from one another. In Trotter's own words :—" The advantages of the median operation are that, when exactly carried out, it is almost entirely bloodless, that it follows a natural line of cleavage, that infective complications are almost non-existent, and that it gives the best access in the direction in which it is most needed."

The application of the method is a little more difficult in practice than the description implies, as it is not always easy to find and follow the exact mid-line of the tongue, but growths which involve the base of the tongue and do not spread far from the mid-line are much better exposed by this method than any other, and the functional result after closure is excellent. The steps of the operation concerned with the removal of the growth, and the subsequent repair, are described on p. 1591.

5. **Lateral pharyngotomy.**—This operation again is associated with Trotter's name. He used it extensively for the exposure of growths in the lateral part of the pharynx and the post-cricoid region and, although it does not share the immunity from septic complications which the median approach enjoys, it gives an exposure of the lateral pharyngeal region superior to that attainable by any other method. The pharynx cannot be exposed from the side without going across the glandular areas, so the operation should generally commence with a glandular dissection. The area of the dissection must then be shut off before the pharynx is opened. This is done by stitching the anterior edge of the sterno-mastoid (or what is left of it if some has been removed with the glands) to the pre-vertebral muscles behind the pharynx. A small triangular gap at the upper end of this suture line is closed by stitching into it the divided posterior belly of the digastric. The gland cavity thus segregated is drained for 24 hours by a tube through a puncture in the posterior triangle. Experience has shown that these precautions are effective.

6. **Transthyroid pharyngotomy.**—The operation of transthyroid pharyngotomy, which exposes the lateral wall of the pharynx below the base of the tongue by removal of the thyroid ala and the great cornu of the hyoid on one side, is an excellent one. It allows palpation of the growth from outside before the mucosa is opened and, even if wound sepsis results, it does not involve great danger of secondary hæmorrhage, as the external carotid artery itself need not be divided and can be segregated from the septic area in the manner described above. Trotter pointed out the danger of secondary hæmorrhage after division of this artery near its origin, and the danger is inseparable from a lateral pharyngotomy at a higher level than the cornu of the hyoid. Such an operation may be the only possible method of approach for growths involving the lateral side of the base of the tongue and the lateral pharyngeal wall, but it should only be undertaken with the understanding that the technique is not easy and the mortality is high.

The incision starts over the mastoid process and extends down to the middle of the anterior border of the sternomastoid. From here it extends forward across the upper border of the thyroid cartilage, and curves upward to end in the submental region. The flap of skin and platysma is turned upward and, after division of the common

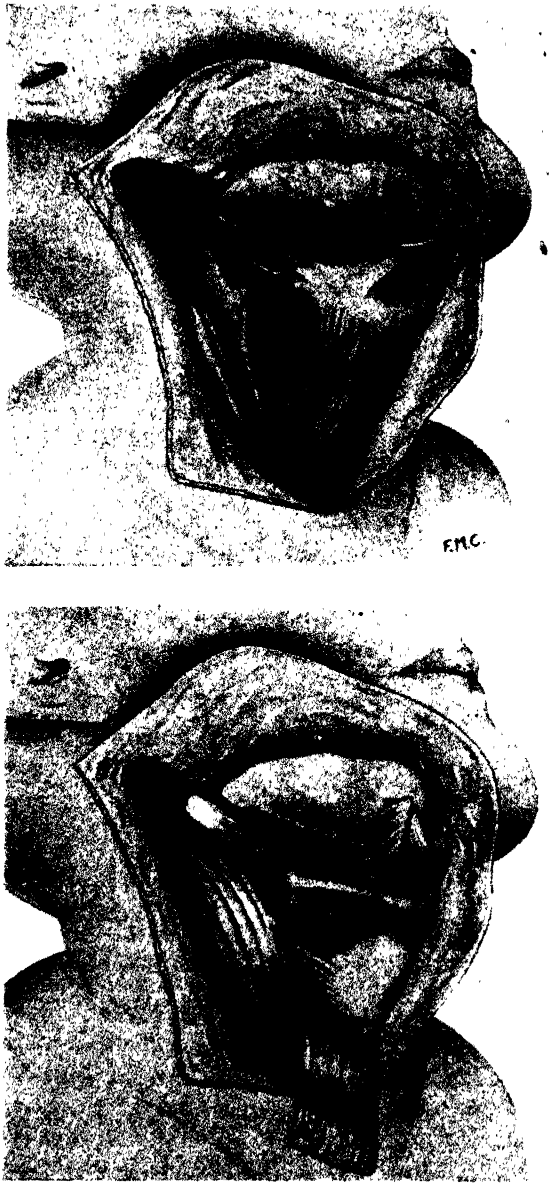

Fig. 729.—Transthyroid pharyngotomy.

facial vein, the glands over the carotid sheath are removed, and the external carotid artery ligatured and divided. The lower end of the parotid gland is freed and turned upward, exposing the angle of the jaw ; the posterior belly of the digastric muscle and the occipital artery are divided, so that the contents of the submaxillary triangle may be either removed or turned forward and upward. The anterior part of the middle constrictor of the pharynx is now exposed, together with the muscles running into the side of the tongue. (Fig. 729.) The outer and posterior extent of this exposure is very limited in its upper part, but it can be considerably increased by freeing and removing the posterior part of the angle of the jaw without interrupting the continuity of the bone. As Trotter pointed out, there is a great disadvantage in this method in that the growth cannot be palpated and its extent estimated before opening the pharynx, so that the next step must be the opening of the pharynx in a part to which it is thought that the growth has not extended. The exposure of the side of the base of the tongue which is gained by this method is excellent, and very large growths may be removed by its use. Various extensions are possible, and in case of necessity practically the whole of the ascending ramus of the jaw may be removed in continuity with the growth without greatly increasing the danger or the difficulty of the operation. (Fig. 730.)

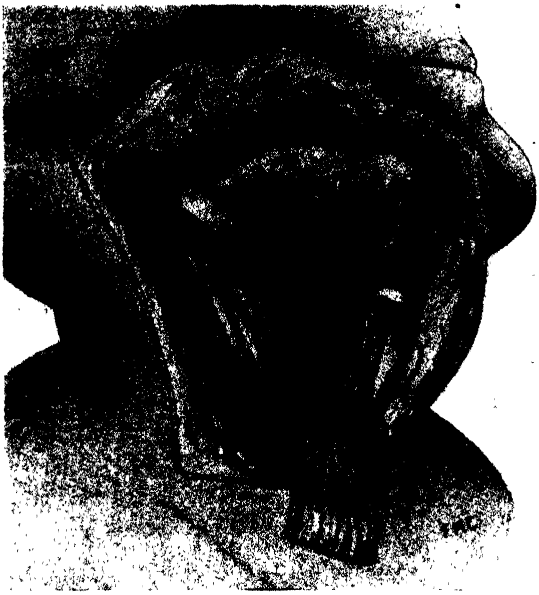

Fig. 730.—Transthyroid pharyngotomy ; exposure completed.

The anxieties of the post-operative period are due mainly to the fear of sepsis and of pulmonary complications. The risks of the former are much greater if attempts are made to close the external wound when the reconstruction of the mucosa of the mouth has been difficult or unsatisfactory. If there is any doubt of the possibility of efficient closure of the mucosa, it is much better to leave a fistula which can be repaired at a later date, and in some cases it is better to plan the skin incision with this object in view. An incision providing a skin flap which can be turned into the gap in the pharynx at the end of the operation is part of the regular technique in Trotter's method for approaching growths of the hypopharynx. If reasonable care is taken to preserve from infection the tissues which are to be covered by the flap and to unite the flap to the raw areas by suture of surface to surface rather than edge to edge, something approaching primary union can be obtained in many cases. This plan may be adopted in pharyngotomy at a higher level if it is thought that the extent of the growth is such that the defect in the pharynx will otherwise be incapable of complete closure. The base of the flap should lie posteriorly so that it can be used to cover the carotid vessels. The patient is fed during the post-operative period by a rubber catheter introduced into the distal part of the pharyngeal opening.

In a personal communication Trotter* wrote :—" I am now convinced that in a lateral pharyngotomy no attempt should be made to secure primary closure of the pharynx. In every case the operation from the first should be designed deliberately to terminate with the making of a temporary fistula. The object of this is to secure the immediate and complete covering-in of all raw surfaces. This change in technique has greatly reduced the danger of serious sepsis and the gravity of the operation. Closure of the fistula under local anæsthesia some weeks later is a trivial matter."

All operations which involve laying open the tissue planes of the neck to infection from the mouth and pharynx carry a considerable risk of spreading sepsis. There is little doubt that this risk is diminished by packing the wound with sulphanilamide powder or some other sulphonamide preparation. This precaution should never be omitted.

DETAIL OF TREATMENT OF GROWTHS IN VARIOUS SITES

Note.—Where reference is made to interstitial irradiation in the following section, it is assumed that the needles used are approximately of the strength, dimensions, and linear intensity recommended on pages 1551 to 1554. For needles which differ markedly from this specification, the technique described is completely unsuitable.

Carcinoma of the lip.—Most growths of the lip tend to remain localized for long periods. They are easily accessible, both for operation and irradiation, and the results of treatment in early and moderately advanced cases are good whichever method is used. In the hands of those who are familiar with its use, radium produces cosmetic results which cannot be equalled by operative methods. Operation, on the other hand, gives the opportunity for biopsy which pure irradiation does not.

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* Who died in Nov., 1939.

Technique of interstitial irradiation.—The shape of the lip lends itself to a simple arrangement of needles, and experience has shown that in the typical case it is unnecessary to irradiate widely beyond the visible margins of the growth. A small growth may be adequately treated by the insertion of a single needle of suitable screening and linear intensity, in the middle of the substance of the lip, parallel to the mucocutaneous junction. If the growth extends further into the substance of the lip it may be necessary to supplement the dose with additional needles, but the technique is always simple, as the dimensions of the lip are such that its whole thickness is adequately irradiated by a needle in the middle of its substance, so that, by applying the principles stated on page 1551, a growth of any size or shape can be completely irradiated without difficulty (Fig. 725).

Distant irradiation is not recommended in typical cases of carcinoma of the lip, as the widespread reaction which it produces incommodes the patient much more than interstitial irradiation, without giving any compensating advantage. In the rare cases in which the growth is of an anaplastic type and there is early and widespread glandular involvement, distant irradiation is the method of choice.

Operation.—Operation may be purely local, or may combine the attack on the lip with the treatment of the glandular areas. The diathermy knife should not be used, as it is apt to lead to failure of primary union. Local operation is the correct treatment for small lesions in which the diagnosis is uncertain. As an alternative to interstitial irradiation in typical cases, it is entirely justifiable, and a surgeon who is not working constantly with radium will probably attain better results with the knife.

The old-fashioned "V"-shaped incision is theoretically unsound but, owing to the comparatively benign nature of the growth, it is generally successful in small growths. An alternative method is to make the incisions on either side of the growth diverge from one another for the first 2 or 3 cm., and then converge again below for convenience in closure. (Fig. 731a.) In both these methods the whole thickness of the lip is removed, and hæmorrhage may be temporarily controlled by the fingers of an assistant compressing the coronary vessels. A margin of 0·75 cm. on either side of the obvious limits of the growth on the red margin of the lip should be allowed. In some cases direct closure of the defect by accurate suture of the skin and mucosa gives a sufficiently good result. It is often advisable to make use of one or two tension stitches tied over pieces of rubber tubing, and operations which involve much loss of tissue generally require some sort of plastic repair. Many operations have been devised and described to serve the purpose. Lateral incisions extending either straight outwards, or outwards and downwards from the apex of the "V," or from the lateral extremities of the diamond left by the primary excision, release tension enough to allow the cut edges to be united, but the narrowing of the mouth may closure of the mucosa, it is much better to leave a fistula which can be repaired at a later date, and in some cases it is better to plan the skin incision with this object in view. An incision providing a skin flap which can be turned into the gap in the pharynx at the end of the operation is part of the regular technique in Trotter's method for approaching growths of the hypopharynx. If reasonable care is taken to preserve from infection the tissues which are to be covered by the flap and to unite the flap to the raw areas by suture of surface to surface rather than edge to edge, something approaching primary union can be obtained in many cases. This plan may be adopted in pharyngotomy at a higher level if it is thought that the extent of the growth is such that the defect in the pharynx will otherwise be incapable of complete closure. The base of the flap should lie posteriorly so that it can be used to cover the carotid vessels. The patient is fed during the post-operative period by a rubber catheter introduced into the distal part of the pharyngeal opening.

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Most surgeons at the present day consider that it is wrong to combine immediate plastic repair with any primary operation which involves considerable loss of tissue. In operations for malignant disease, excision of an adequate margin of apparently normal tissue is the primary consideration, and it is well that the surgeon's mind should not be distracted from this by the necessity for considering means of repair. Furthermore, recurrence of growth in a wound which has been repaired at the expense of the surrounding tissues is very difficult to treat, and from this point of view also it is better to delay plastic repair until sufficient time has elapsed to show that the excision has been sufficiently radical. In some cases it will be found that even after a very extensive excision the patient suffers so little discomfort that he prefers not to submit to any further operation. Fig. 732 shows the end result ten years after the operation of excision for an epithelioma involving practically the whole of one side of the lip. The patient did not wish to submit to any further operation and he is comfortable and free from symptoms.

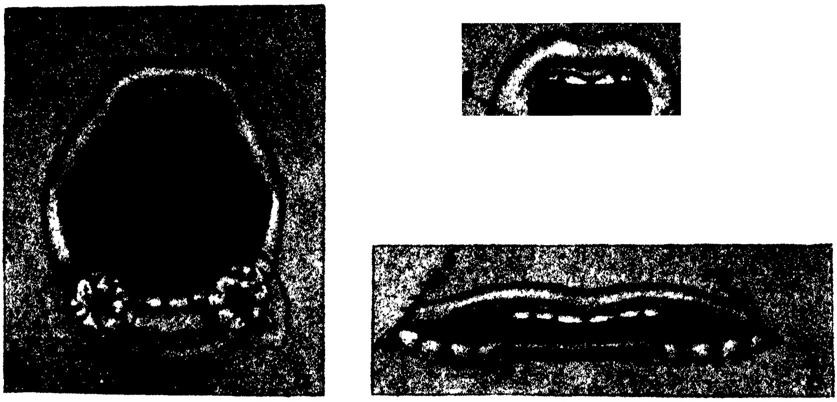

Fig. 731.

a, incisions for local removal of epithelioma of lower lip ; b, an epithelioma has been excised from the lower lip. Primary union has been obtained, but the narrowing of the lower lip has produced an ugly pouting deformity of the upper lip ; c, plastic repair. Incise the full thickness of the lip along A, B, C. Unite A, B to B, C. This straightens the upper lip but leaves a raw margin A, D along which the skin and mucosa are united by direct suture to form the lateral part of the lower lip.

Recurrence of growth between the primary lesion and the glandular areas is uncommon, and it is generally better not to attempt operations combining the treatment of the two. However, such operations do not carry the same mortality in the lip as they do in the tongue and, if it is thought desirable, the lower end of the wound left by the primary excision may be extended into the submaxillary triangle, so as to make it possible to remove the tissues of the submaxillary triangle and the growth, together with the strip of deep fascia uniting them. If this is done, it is better not to incise the mucous membrane of the lip until the end of the operation, so as to avoid the possibility of contaminating the tissues of the neck with septic material from the mouth. The case shown in Fig. 732 was treated by this method as there was very little normal tissue between the growth and an infected submaxillary gland.

If it is decided not to excise the glands in continuity with the primary growth, their treatment still remains a very important consideration. The surgeon must not allow himself to be deceived by the fact that very many cases of carcinoma of the lip remain permanently free from recurrence after treatment of the primary growth alone. The five-year cures are 25 to 30 per cent. higher in series of cases in which the glands have been treated as if they were infected, irrespective of whether they were palpable or not, than in those in which the primary growth only has been treated. This does not necessarily mean that a radical gland dissection must be undertaken in every case, but patients who cannot be kept under regular observation should always be treated as if the glands were infected. The question is further discussed on p. 1594.

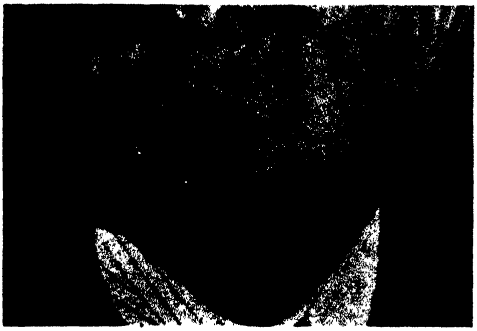

Fig. 732.—Large carcinoma excised in continuity with infected submaxillary glands. No attempt at plastic repair. Result ten years later.

Carcinoma of the floor of the mouth.—Growths which come under this heading are fairly constant in position and type. They generally start in the region of the orifice of the submaxillary duct, and tend to spread laterally over the alveolus and upwards into the substance of the tongue, so that in many cases the tongue is dimpled over the growth when fully protruded. They have no very marked tendency to widespread glandular involvement and, as Butlin noted many years ago, they are much more amenable to treatment than their formidable appearance would suggest. Estimates of the five-year survivals vary very widely. The correct figure is probably about 40 per cent. if a very large series of cases be taken, but there are several available records which show results much better than this.

For those practised in the use of radium, irradiation is preferable to operation in ordinary cases, as it averts both operative mortality and subsequent deformity. If the bone of the lower jaw is involved deeply enough to show X-ray changes, the chances of cure are small in any case, but they are then certainly greater with operation than with irradiation provided a free removal of a large section of bone is made.

Technique of irradiation.—The technique here described has given excellent immediate results in my hands. Since the description was written, two of my cases, cured of growths in the floor of the mouth, have returned with spontaneous necrosis of the lower jaw, one six and the other seven years after treatment. There is no doubt that the use of irradiation in growths of low malignancy, such as carcinoma of the floor of the mouth, exposes the patient to the risk of remote complications of this type. It is still too early to say whether this risk is great enough to suggest that operation is still, in spite of its immediate mortality, the safer form of treatment.

The region affected by the growth is not easily accessible from the mouth unless the lower alveolus is much atrophied. In other cases it is almost impossible to space needles accurately from within, and it is much better to insert them through the submaxillary triangle, remembering that, if there are extensions into the tongue and over the alveolus, they are not accessible from below and must be treated separately.

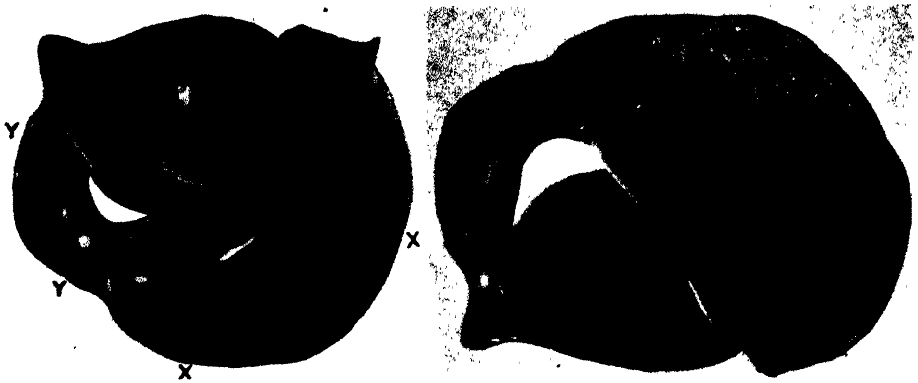

Fig. 733.—Applicator for surface irradiation of right lower alveolus.

A, applicator viewed from the front. The large compartment XX accommodates the tongue and the left lower alveolus. Radium is embedded in the portion YY which lies over the growth. The unaffected parts of the mouth are protected mainly by the arrangement of the apparatus which ensures that they are kept at a distance from the radium. B, Gingival aspect: The chamber which contains the tongue and the left lower alveolus is lead lined. *Photo by Brian Stanford.*

The alveolar extension cannot be treated by the interstitial method without inserting needles directly into the bone. Necrosis is almost certain if this is done, so it is better to treat such extensions by a preliminary surface irradiation on the following lines.

The teeth in the neighbourhood of the growth are extracted, and a dental applicator is prepared which covers the floor of the mouth and the part of the alveolus involved (Fig. 733).

In the surface of the applicator which lies against the growth small radium needles are embedded, allowing 1½ to 2 mgm. of radium to each square centimetre. The applicator is worn for 8 hours in the 24, over a period of seven days. This dose is sufficient to arrest the superficial spread, and a week or so later interstitial irradiation is carried out by inserting needles from below upwards in the submaxillary triangle, the dosage being about $\frac{3}{4}$ of a mgm. for 7 days for each cubic centimetre of tissue.

The whole of the tissues of the submaxillary triangle is irradiated, the outermost row of needles being placed close to the inner side of the lower jaw. Their position is controlled by a finger in the floor of the mouth during the insertion. The risk of immediate necrosis of the jaw is not great, but if needles with an extra screen of 0·3 to 0·5 mm. of platinum are available, they may be used for insertion against the bone. If the substance of the tongue is indurated, or its surface is retracted when protrusion is attempted, this is taken as evidence of upward extension of the growth, and one or two additional needles are placed longitudinally on the side of the tongue (Fig. 734 c).

This technique irradiates not only the primary growth and its extensions, but also the lymphatics of the submaxillary region. It is very suitable for cases which show no evidence of glandular metastases, but it has the disadvantage that it impairs the nutrition of the tissues of the submaxillary triangle, and makes them unsuitable for subsequent operative procedures. The glands under the sternomastoid may be dissected out at any time after the inflammatory reaction has subsided, but if the operation is extended to the submaxillary region there is serious danger of sloughing and delayed healing.

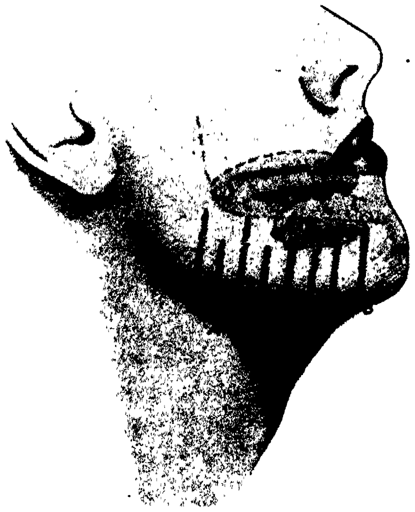

Fig. 734.—**Interstitial irradiation of carcinoma of floor of mouth.**

The needles AA are inserted through the skin of the submaxillary triangle just above the hyoid bone and project directly upwards. The row BB is inserted just internal to the mandible. Both these groups of needles should be about 2 cm. in length. BB should if possible carry an extra screen. CC are two needles inserted horizontally into the substance of the tongue where the growth extends upwards on the hyoglossus. They should be 3–4 cm. long.

The technique I adopt is to irradiate the primary growth and the submaxillary region in the manner described, and to leave the remaining glandular areas untreated. The patient is kept under close observation and, if there is reason to suspect at any later period that the glands are invaded, a gland dissection is undertaken, and is either made complete, or limited to the anterior triangle of the neck, according to the condition of the submaxillary tissues. Cases which show obvious metastases under the sternomastoid when they first present themselves for treatment are not suitable for the technique described. If the metastases have appeared quickly, or if they advance rapidly under observation, there is little hope of complete cure, and it is better to treat them, together with the primary growth, by distant irradiation with the radium bomb, with a view to obtaining at least a good palliative result. Operation is unlikely to succeed permanently in this type of case, but it should be tried if large numbers of radium needles and the facilities for using them are not available.

If, on the other hand, metastases are widespread, but of a slowly growing type, there is a reasonable prospect of cure if a complete gland dissection is carried out, and this operation becomes the primary consideration. In these circumstances the tissues of the submaxillary triangle must not be irradiated, and if the primary growth is too large to be irradiated from the mouth it is better treated by operation.

Operation.—Small growths may be excised from within the mouth, but the difficulties of access are considerable, and the operation is unsatisfactory if the growth is close to the lower jaw, and also if it appears to infiltrate tissues below the submucosa. For superficial, freely-movable ulcers diathermy may be used, either for coagulation or for excision, but the possibility of secondary hæmorrhage and the difficulty of controlling it in this situation must not be forgotten. The submaxillary duct is inevitably divided or injured, but no steps need be taken to reconstitute the opening.

For larger growths the best means of approach is by median division of the jaw. The preliminary steps may be carried out as detailed on p. 1559, and the growth approached from below and in front after dissection of the submental glands, but without disturbing the tissues of the submaxillary triangle. If, as often happens, the growth involves the side of the tongue, a wider exposure is necessary, and it can only be obtained by clearing the submaxillary triangle. The lower end of the skin incision is turned posteriorly above the hyoid and carried backwards along the line of the posterior belly of the digastric muscle. Before dividing the jaw a flap consisting of skin, subcutaneous tissue and platysma is turned up far enough to expose the facial vessels where they cross the lower border of the jaw and the lymph gland which lies on them at this point. The vessels are then divided distal to the gland and the deep fascia incised along the lower border of the jaw as far forward as the mid-line. Returning to the posterior part of the wound, the facial vessels are isolated and divided between the posterior belly of the digastric muscle and the submaxillary gland. The digastric muscle is divided posteriorly and turned forward, together with the submaxillary gland as far as the posterior border of the mylohyoid. The hyoglossus is now exposed, and the hypoglossal nerve may be defined and the lingual artery ligatured. The capsule of the submaxillary gland and the digastric tendon are freed from the hyoid bone and turned upwards on the mylohyoid. The posterior part of the wound is packed with gauze soaked in flavine and, returning to the anterior part, the margins of the growth are defined and a decision is made as to whether it is necessary to remove any part of the jaw. The site of division is dictated by this decision, and the jaw is either divided just to one side of the middle line, after separation of the muscles from its inner aspect, or the involved segment is isolated by division on either side of it. The mylohyoid is now divided between the jaw and the hyoid, the actual site of division being again dictated by the extent of the growth, and the posterior end of the growth is exposed by pulling the divided half of the jaw backwards on the affected side and freeing the mucosa from it. The lingual nerve and the mucous membrane of the floor of the mouth are divided behind the growth, which is turned forward together with the deep part of the submaxillary gland, and the sublingual gland. This leaves the growth attached by its inner border to the side of the tongue and, owing to the characteristic mode of extension, it is often necessary to remove a portion of the tongue with it. There is no objection to doing this, and it may actually be an advantage in the subsequent closure of the floor of the mouth.

Closure after this operation involves reconstruction of the mucous lining and, as far as possible, of the musculature of the floor of the mouth. The ease with which it is attained depends on the amount of tissue removed, but in most cases the mucosa of the tongue can be freed and drawn across to meet the lower jaw so that by suturing carefully from behind forwards, and apposing raw surface to raw surface, rather than edge to edge, very fair results can be attained.

Tissues which are sewn together under tension inevitably break apart and, if there is difficulty in making the edges of the mucosa meet, tension stitches may be inserted through the substance of the tongue and carried round the lower jaw to be tied externally. These stitches tend to become loose by cutting into the tongue in a few days, but in the immediate post-operative period they serve both to relieve the tension on the suture line and to prevent the tongue from dropping back into the pharynx, which it is apt to do as a result of the division of its anterior attachments.

The divided jaw is united with silver wire. If it has been necessary to remove a portion of the whole thickness of the bone, healing produces a deviation of the chin to the affected side. Attempts may be made to prevent this by dental appliances, but they are not generally satisfactory, and it is better to allow healing to take place and to undertake subsequent plastic operation if necessary. The skin flaps are loosely united, and drainage is provided as far up as the reconstructed floor of the mouth.

This operation is designed not to encroach on the carotid sheath, so as to leave the field open for subsequent dissection of the deep cervical glands at a separate operation.

Operations designed to remove the growth and clear the whole of the glandular areas at one sitting are unsound, because of their high primary mortality and the risk of severe sepsis. It is technically somewhat easier to perform the operation on the glands before removing the primary growth, rather than after, but the weighty objections to this order outweigh the technical advantages.

Carcinoma of the lower alveolus. Operation.—Papillary growths are best approached from inside the mouth. If necessary the cheek may be split as described on p. 1558. The mucous membrane is first incised a full half-inch away from the margins of the growth, so as to surround it completely. Diathermy is helpful in this part of the operation, as the absence of oozing which attends its use makes it easier to define the margins of the growth. The mucosa is dissected up towards the affected part of the alveolus, and the operation is completed by removing a segment of the bone with a gouge or chisel.

Growths of the infiltrating type should be studied carefully before operation as they often extend more widely than their superficial appearance suggests. Particular attention must be paid to expansion of the body of the jaw and to X-ray appearances. These growths must be approached by an external incision along the lower border of the jaw, and the only chance of success is an unhesitating sacrifice of as much bone as is necessary to leave a margin of half an inch or more from the obvious limits of infiltration. Attempts at sparing the bone to avoid deformity are certain to end in recurrence, and the jaw must even be divided behind its angle if this appears necessary. As ulceration is not a prominent feature of these growths, sepsis is less formidable than in many other mouth operations, and it may be justifiable to insert a bone graft between the fragments of the jaw at the time of the primary excision. It is not worth making this attempt unless it is possible to close the mucous membrane accurately over the graft, and even so, the graft is generally absorbed sooner or later. While it survives it performs a useful function in splinting the jaw while the surrounding soft parts heal. The end results of removal of large segments of the jaw are not so bad as they are commonly supposed to be, even if regeneration fails completely, and in my view the chief function of a bone graft in the jaw is to act as an internal splint during healing. Function is often surprisingly good as long as the graft survives, and Fig. 785A shows a case three weeks after excision of the whole of the right side of the body of the jaw.

The ultimate result of loss of one side of the body of the jaw and complete failure of regeneration is shown in Fig. 785B. This patient is leading a normal life and is able to eat solid foods.

Glandular invasion is not a prominent feature of the infiltrating type of growth, possibly because it is so often fatal from other causes at a comparatively early stage. Both in the infiltrating and the papillary type, treatment of the glandular areas is a separate problem, and should be dealt with on the lines laid down on p. 1594.

Carcinoma of the upper jaw.—Papillary growths which are limited to the alveolar margin may be treated either by operation or irradiation. Owing to the spongy nature of the bone involved, interstitial irradiation is not contra-indicated as it is in the lower jaw, and needles may be inserted through holes bored in the alveolar margin, so as to

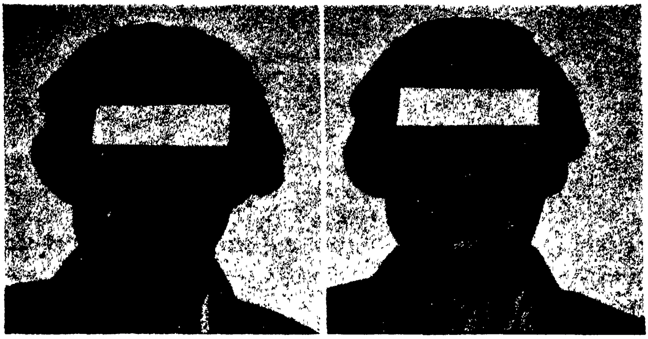

Fig. 735A.—Photographs of a patient three weeks after resection of the jaw from the middle line anteriorly to the angle posteriorly.
(Reproduced, by permission, from *The Lancet*, March 25th, 1939).

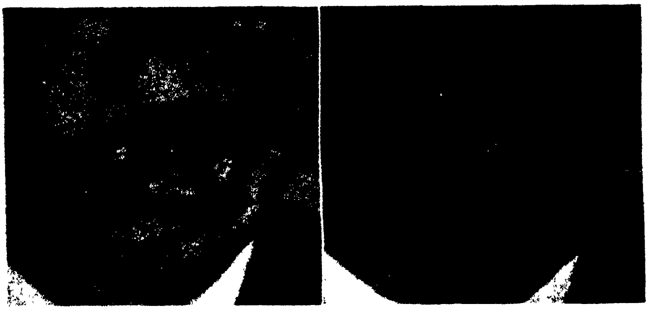

Fig. 735B.—Function and appearance following removal of the right side of the body of the jaw from the midline to the ascending ramus. No attempt has been made to restore the lost bone.

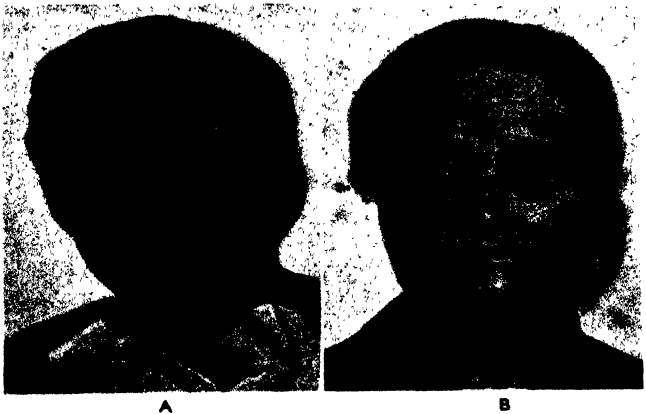

Fig. 736.—Submucous infiltrating tumour of upper jaw.
A, before treatment ; B, six weeks later after mass irradiation.
(Reproduced, by permission, from *The Lancet*, March 25th, 1939.)

irradiate the growth on the principles which are applied to the soft tissues. A few small spongy sequestra generally result, but they do not influence the course of the recovery, and are of no serious significance. (Fig. 786).

Operation.—Operation may equally well be employed in such cases. For a small growth it is best to start by marking out the limits of the proposed excision with the diathermy knife. Mucous membrane incised in this way does not bleed, and consequently makes it easier to be sure that an adequate margin of normal tissue has been left. The diathermy incision is carried down to the bone. It is always wise to remove the part of the alveolus which lies beneath the growth and this is best done by dividing it with a sharp chisel. The mucous membrane of the maxillary antrum is generally exposed, but if possible it is left intact and subsequently inspected to make sure it is not involved in the growth. Cases which are suitable for this operation do not require removal of the bone of the hard palate. If this is involved the whole excision must be planned on more generous lines.

The immediate results are very satisfactory when performed on suitable cases. Sepsis is not marked, and the raw surface epithelializes rapidly, so that in a few weeks a dental apparatus can be fitted to cover the defect. The most usual cause of disappointment is failure to realize the extent of the growth, so that an apparently successful local excision is followed by recurrence before healing is complete. The lymphatic drainage of this area is mainly in a posterior direction in accordance with the vascular supply, and it is generally in the posterior part of the wound that recurrences originate. It is therefore essential for the surgeon to assure himself as far as possible that the growth really is a limited one before he plans and undertakes a limited operation.

Extensive growths of the upper jaw.—There are three types of extensive growth in the upper jaw, and each has its own appropriate treatment.

(1) **Growths which tend to spread widely and deeply with comparatively little ulceration.**—This is the type in which the extent of the growth is inferred by the presence of such signs as pain of trigeminal distribution and ophthalmoplegia, rather than by direct physical signs. These cases are quite unsuitable for operation. Like many other growths which extend beneath the mucous membrane without ulceration, they are highly radiosensitive, and may be greatly improved by irradiation. During the period of improvement, which may last a year or two, pain and paralysis may disappear entirely, and the local condition return to normal. These growths have many points in common with the lympho-epithelioma of the posterior third of the tongue, and like them they have so strong a tendency to ultimate uncontrollable metastasis, that five-year cures are uncommon.

Interstitial irradiation should not be used in this type of case if mass irradiation is available. The complicated anatomical structure of the part and the irregular extension of the growth among the bones at the base of the skull make it very difficult to distribute needles evenly, and it is possible that the introduction of infection which is inseparable from numerous needle punctures reduces the radio-sensitivity of the growth. Teleradium is probably more suitable than X-ray therapy.

(2) **Ulcerating growths which have not extended beyond the limits of the upper jaw.**—The classical operation of excision of the upper jaw, modified to suit the requirements of each particular case, is very satisfactory in these circumstances. Considering the extent of the operation, shock is remarkably slight. Drainage is necessarily free from the beginning, so that severe sepsis is rare, and neither coughing nor swallowing are interfered with enough to predispose to pulmonary complications. By suitable modifications of the classical operation a very good facial contour may be preserved and, provided the cases are carefully chosen, this is one of the most satisfactory of the major operations in the buccal cavity.

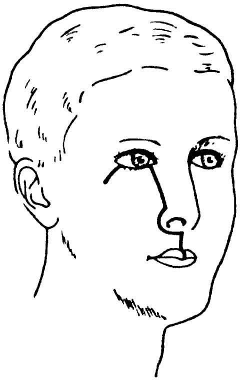

Fig. 737.—Incision for removal of the upper jaw (Trotter's modification).

The incision follows the classical

Steps of the Operation

Preliminary ligature of the external carotid artery is an advantage. If this is not done, bleeding may be very free and, although it is not often enough to endanger life, it is sufficient to obscure the operative field and lead to difficulty in adhering to the original plan of the operation. Accordingly, it is generally better to reverse the usual order of procedure and to complete the dissection of the cervical glands, together with ligature of the external carotid artery, before operating on the primary growth. The main operation is undertaken about two weeks later.

The skin incision follows the classical lines by dividing the upper lip and following the boundaries of the nose so far as the inner canthus. At this point it is much better to adopt Trotter's modification, and carry the incision through the conjunctiva just internal to the margin of the lower lid, rather than through the skin of the lower lid itself (Fig. 737). This is easily done by carrying the incision across the lower eyelid just lateral to the orifice of the lachrymal duct, and introducing one blade of a pair of scissors into the loose subconjunctival tissue at this point; it avoids the ugly deformity which is likely to result from that interference with the lymphatic drainage of the lower lid which the classical operation produces. From the outer canthus the incision is carried an inch or so downwards and outwards through the skin of the cheek, down to the bone, and a flap consisting of the whole thickness of the cheek is prepared. As this flap is turned back the mucous membrane of the gingivo-buccal sulcus is cleanly divided well away from the margin of the growth.

The subsequent steps of the operation depend on the extent and nature of the growth. If there are signs, such as expansion of the jaw or infra-orbital pain, which suggest wide involvement of the antrum, it is best to follow the classical procedure and to free the upper jaw intact by elevating the periosteum of the floor of the orbit and dividing in turn the malar, frontal and palatal attachments of the bone. This leaves the maxilla attached posteriorly to the pterygoid laminæ from which it should be gently separated by a curved periosteal elevator introduced from behind on the outer side. Attempts to seize the bone, and twist it out without dividing its posterior attachments usually result in crushing the walls of the antrum if they are invaded by growth and involve the risk of implanting carcinoma cells in the raw tissues of the wound. The maxillary nerve is usually drawn out with the jaw as it is separated, and should be divided far back. Hæmorrhage is considerable for a few moments, whether or not the carotid artery has been ligatured, and is best controlled by plugging. The skin incisions should be accurately sutured, as healing by first intention can generally be obtained, but the facial contour is marred by the sagging of the tissues of the cheek and the consequent displacement of the eye. Various methods have been suggested for overcoming this difficulty (such as the provision of a sling, fashioned from the temporal muscle, passing from without inwards beneath the periosteum of the orbit) but none of them are very satisfactory, and patients on whom the classical operation has been performed generally have to wear an eye shade. In dealing with growths which do not invade the antrum widely it is often possible to spare the upper bony wall of the cavity. If this can be done, the cosmetic result is greatly improved and, after provision of a suitable denture, there is little visible deformity.

When there is definite involvement of the orbit, as shown by displacement of the eye and infra-orbital anæsthesia, it is certain that no operation can be curative without sacrifice of the eyeball. As soon as this is recognized an extension of the operation is possible which makes it much more hopeful. The removal of the maxilla should then be combined with that of the malar bone and complete exenteration of the orbit. The operation is little more serious than the classical excision of the upper jaw and its results, in suitable cases, are far better. The resulting deformity is easily concealed by an ordinary eyeshade.

(3) **Ulcerating growths which have spread beyond the limits of the upper jaw and are invading the cheek, the tissues in relation to the lower jaw, or the lateral wall of the pharynx.**—Growths of this type are not necessarily hopeless, as some of them belong to the superficial spreading group, and may be arrested if a sufficient margin of tissue beyond their growing edge is treated. They are not very suitable for operative removal, as adequate exposure of their various extensions is difficult to obtain by any surgical operation save the most extensive. Some

of them react well to irradiation. Interstitial or teleradiation may be used, and it is not possible to say which gives the larger proportion of cures.

For growths in which the limits of the extensions can be appreciated by sight and touch, interstitial irradiation may be applied. In such cases needles inserted horizontally on either side of the ascending ramus of the mandible may be used to inhibit the posterior extensions, while the main mass of the growth is treated by smaller needles passing transversely through the upper alveolus. Neither the palate nor the tissues lying in front of the angle of the lower jaw are easy to irradiate by the interstitial method because of the small depth of tissue available to carry the needles, but the difficulties can usually be overcome sufficiently to attain a reasonably uniform distribution. Cases in which there is a great deal of destruction of bone are ultimately hopeless, and palliative results are probably better with teleradium than with the interstitial method. Cases with marked glandular involvement, which may equally well have invaded glands along the course of the external maxillary artery, are likely to fail if treated by any means which does not include this region. Thus the field for interstitial irradiation in extensive growths of the upper jaw is limited to those which spread superficially beyond the limits of the jaw, but show no strong tendency to glandular involvement or destruction of bone. Here, as elsewhere, success depends upon uniform distribution of radium and the avoidance of irregular dosage.

The only way to attain uniformity in this very complicated region is to plan the details of the irradiation separately in every case, and to carry it out with all the care which would go to a major operation. If this is done, in suitable cases, interstitial irradiation can give very excellent results at the expense of comparatively little discomfort to the patient. Used indiscriminately and without attention to detail. its results are very bad.

Carcinoma of the cheek.—Reference has already been made to the difficulty of distinguishing carcinoma from tuberculous ulceration in this region. Carcinoma is very much more common, but unless there is some very strong contra-indication, biopsy should always be made before the main treatment is commenced.

In early or moderately advanced cases of carcinoma of the cheek, interstitial irradiation is easy to carry out, and gives excellent results. The ulcer generally starts in the neighbourhood of the orifice of the parotid duct, and spreads evenly from its centre, producing a circular lesion. While it is in this form a simple pallisade arrangement of needles suffices to cause the disappearance of the lesion. The needles should be placed deeply enough to lie in the plane in which obvious infiltration of the tissues of the cheek ceases, and, if this is done, there is no necessity to risk necrosis of the skin by inserting a second layer. Teleradiation presents no advantage over the interstitial method.

Growths which start far back, or those which have been neglected long enough to spread on to the alveoli, do not give the same good results with irradiation and are better treated by operation.

Operation.—Localized growths in the cheek may be excised from within the mouth. More extensive growths are better approached by an incision running backwards from the angle of the mouth. The steps of the operation for excision require no special description, but it is essential that the margin of apparently normal tissue behind the growth should be adequate. Whatever method is used, there is necessarily a considerable sacrifice of mucous membrane and sometimes of skin. Attempts at immediate plastic repair are often inadvisable for the reasons stated on p. 1574, but it must be remembered that healing by granulation is certain to cause contracture and, if no attempt is made to replace the lost epithelium, the patient should be encouraged to use a wedge or a gag two or three times a day to prevent trismus

Diathermy is apt to cause necrosis of the skin and most surgeons in this country avoid it.

Norman Patterson has recently described a method of excision which has the advantage of permitting diathermy for the removal of the growth itself without involving the risk of necrosis. He marks out a flap consisting of skin only by an incision commencing at the pinna and following the posterior and lower border of the mandible as far as the mid-line. This flap is turned upwards far enough to allow complete exposure of the external aspect of the growth. The facial vessels are then defined and excised from the point where they cross the mandible to that at which they disappear into the base of the flap, so as to preclude the possibility of a later secondary hæmorrhage. If it is necessary, in order to secure an adequate exposure of the growth, a part of the masseter and the ramus of the jaw is removed. Having thus completed the exposure of the external surface of the growth, Patterson gags open the mouth and excises the growth, together with an adequate margin of normal tissue, by diathermy, working from inside the mouth. The skin flap is then replaced and secured in position. (Fig. 738).

This operation necessarily destroys the greater part of the parotid duct in most cases but, according to Patterson, no untoward symptoms are likely to arise as a result.

The method makes no attempt at reconstituting the epithelial lining of the inner surface of the cheek, and a wedge or gag must be used by the patient until healing is complete.

CARCINOMA OF THE TONGUE

Very wide divergences of opinion on the correct treatment for carcinoma of the tongue have existed for many years, and the popularization of treatment by irradiation has increased rather than diminished the perplexities. The fact that a number of different treatments are in use indicates that no one of them is entirely satisfactory, and reference to the section of this article dealing with prognosis will show how very far we are at present from a satisfactory solution of the problem. *The greatest measure of success will be obtained by the surgeon who familiarizes himself with all available forms of treatment, and uses them discriminatingly according to the type and stage of the growth with which he is dealing.* There are many cases to which several forms of treatment are applicable with equal prospects of success, and in these the surgeon should choose the method with which he is most familiar. There are others which should always be treated by irradiation if it is available, and still others in which operation is the method of choice.

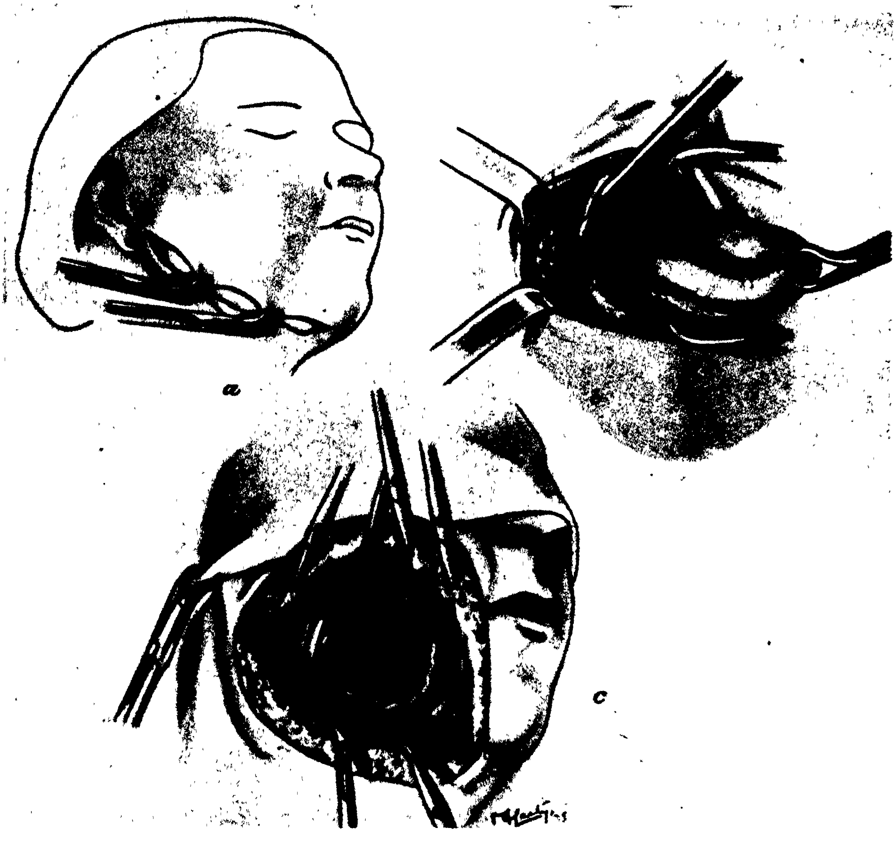

Fig. 738.—Norman Patterson's method for excision of carcinoma of the cheek.
a, skin flap marked out; *b*, commencement of intrabuccal part of operation; *c*, excision completed. The facial vessels have been removed between the mandible and the base of the flap and a piece of the edge of the masseter has been removed. The growth has been excised and the skin flap is ready for replacement. (*Reproduced, by permission, from The British Journal of Surgery*).

The choice of radium or operation in the treatment of a localized primary growth has little influence on the survival rate, provided that both are competently carried out. In large growths the balance is somewhat in favour of radium, but the five-year survivors are so few in either case that from this point of view there is not a great deal to choose between the methods. What is much more important is the question of palliative results. The palliation of an incurable growth with radium is a more difficult technical feat than the cure of a localized one, but it is a possibility. A non-radical operation is a disastrous event which leaves the patient worse off than he was before, so where the means of irradiation, and experience in its use, are available, it should generally be used in preference to a doubtfully radical operation. Irradiation in these conditions requires the most careful thought as regards dosage and application, and unless properly used it can cause quite as much damage as a non-radical operation. It undoubtedly gives much better results in experienced hands, and the fault of inexperience is nearly always excessive and irregular dosage. If this is avoided, the lives of many advanced cases may be prolonged in comparative comfort for periods up to two or three years.

An exception to this rule is provided by cases which show involvement of the dense bone of the lower jaw. In these cases neither cures nor good palliative results are obtainable by irradiation, and the only hope is to stake everything on the chances of a radical operative excision.

I propose, in the following section, to subdivide carcinoma of the tongue by a somewhat arbitrary classification which is partly clinical and partly pathological, and to discuss separately the treatment of each class of case. In doing this it must never be forgotten that the problem of carcinoma of the tongue is inseparably connected with that of malignant invasion of the glands of the neck. No treatment which neglects the glandular areas can be successful in anything but a very small proportion of cases, whatever the stage or form of the disease. Having once realized this fact, it is permissible to consider the treatment of the primary growths first and that of the glands later. The alternative, which is combined treatment, either by operation or irradiation, has its place and must be considered among the other methods, but in many cases the primary growth and the involved glands are separated by apparently normal tissue which forms an invaluable barrier between the septic cavity of the mouth and the tissue planes of the neck. Experience has shown that the application of treatment in any form to this barrier does little to improve the ultimate results, and with a few exceptions growths in the tongue which are clinically separable from the glandular areas should be treated by themselves in the first instance.

(1) Localized growths confined to the mobile part of the tongue.— Growths of this type may be treated either by excision or interstitial irradiation. There is little or no difference in the late results, but irradiation properly performed with suitable needles gives a better functional result and may leave the patient with a tongue practically indistinguishable from normal. It must be recognized that even in what appears to be a successful result, there may be loss of taste and other discomforts.

Excision.—Sufficient exposure can usually be obtained through the mouth, but if necessary access may be made easier by dividing the cheek in the manner already described (p. 1558). The extent of the growth must be estimated by palpation as well as inspection and, before commencing the excision, traction stitches should be inserted at intervals round the growth and about a third of an inch from its margin. Trotter has pointed out that if this precaution is neglected and the excision is performed while the tongue is pulled out by traction stitches in front of the growth, the tissues posterior to it are stretched, and the margin of normal tissue behind the growth may be found on subsequent inspection to be inadequate.

The excision should be carried out so as to leave an even margin of one-half to three-quarters of an inch of normal tissue in all directions.

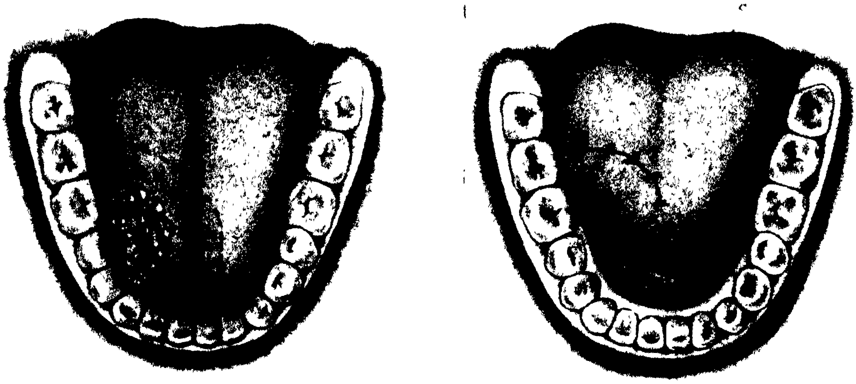

Fig. 739.—Excision of localized growth in anterior part of tongue and repair of the resulting defect.

Operations such as hemiglossectomy, in which the incision follows anatomical boundaries instead of being dictated by the extent of the growth, are unsound, as the lymphatics of the tongue anastomose very freely, and the spread of carcinoma is not confined to any one direction.

Bleeding is not difficult to control and the lingual artery, which is the main source of anxiety, can often be seen before it is divided, lying close to the under surface of the tongue, nearer to the frænum than to the lateral border. If the operation is done with the knife or scissors there is a good prospect of primary union, provided the raw surfaces are brought carefully together and the mucosa lightly sutured. Diathermy wounds much more often break down and may even result in secondary hæmorrhage. If the gap left by the excision is too large to be closed by direct suture, the tip of the tongue may be turned round and used to close the defect as shown in Fig. 739.

Whitehead's method.—This operation has been used with much success in the past, and is suitable for growths which involve the greater part of the tongue without encroaching on the jaw or the floor of the mouth, and for those in which local excision is contra-indicated because of widespread precancerous changes in the rest of the tongue.

Whitehead operated with the patient sitting in a rocking-chair, under general anæsthesia which was allowed to become light in the later stages.* Under modern conditions it is probably better to use the recumbent position with the head propped well forward, the pharynx being plugged and anæsthesia being maintained either by means of a nasal intratracheal tube, or through a tracheotomy.

The mouth is held widely open by an efficient gag, and the tongue is drawn out by a traction stitch passed through its anterior part. The whole operation is done with scissors. The frænum is divided first, and then the mucous membrane where it is reflected from the tongue to the jaw, and later the attachment of the anterior pillars of the fauces is severed. This is a most important step in the operation and should be carried out at an early stage as it facilitates the later stages. Bleeding is considerable, but only spouting vessels need be picked up. At this stage a large curved needle carrying a strong thread stitch may be inserted in the midline between the tongue and the symphysis menti, and made to emerge just in front of the epiglottis. Traction on this stitch delivers the tongue even further, and the epiglottis itself can be brought almost out of the mouth.

Removal of the tongue is now completed by dividing the genioglossi and the muscles of the base of the tongue from before backwards. The lingual arteries are very constant in position (*see* p. 1539), and can usually be picked up with artery forceps before they are divided. Before completing removal of the tongue, a thread stitch should be inserted through the glosso-epiglottidean folds. This suture may be left in place for 24 hours after operation in case it becomes necessary to use it as a tractor for the control of reactionary hæmorrhage or post-operative respiratory obstruction. In the original operation, no attempt at closure of the mucous membrane was made. If closure is thought desirable, the gap in the anterior part of the floor of the mouth may be sutured in a straight line in the sagittal plane and, if it has been found possible to spare a sufficient amount of the mucosa in front of the epiglottis, this can be brought forward to cover the muscular stump of the tongue, so that complete closure is obtained with a " T "-shaped scar.

Irradiation of localized growths.—Interstitial irradiation of localized growths can be carried out satisfactorily by any simple arrangement of needles which conforms in the amount and evenness of distribution with the principles stated on pp. 1550–1554.

Teleradiation is useful when it is desired to treat the primary growth and the glandular areas in continuity. This necessity arises occasionally in small growths when they are of highly anaplastic type and have given rise to secondary deposits which are disproportionate to the extent of the primary lesion. In this case the glands are usually unsuitable for operation, either because of their size or the rapidity of their growth, and it is better policy to treat them and the primary lesion together by teleradiation. The method is also sometimes used for old and feeble patients, but it is doubtful if the upset occasioned is any less than it is with the interstitial method.

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* Whitehead, *Practitioner*, May, 1903, lxx, 585.

(2) **Localized growths developing in a tongue affected by chronic superficial glossitis.**—Induration of the submucous tissue makes it difficult to be sure of the extent or even of the presence of a carcinoma in many cases. For the same reason it is difficult to assess progress after irradiation, and the surgeon may be long left in doubt as to whether the treatment has been successful or not. Moreover, the reaction to irradiation of growths in tongues affected by chronic superficial glossitis is uncertain, and it is best to treat this class of case by operation. If there is any special reason for avoiding operation, interstitial irradiation is justifiable, and may result in a cure.

Unless the whole tongue is removed, primary union is difficult to obtain, even after excision with the knife, but the scars left by healing of unsutured diathermy wounds are generally soft and pliable, and diathermy excision with a low current and no attempt at closure of the wound, is a useful method. Whitehead's operation may be used when the condition of the tongue is such that it is unwise to leave any part of it.

(3) **Growths of the anterior two-thirds of the tongue involving the floor of the mouth or the jaw.**—These growths are really a later stage of Group I and, like them, may be treated with equal success by operation or irradiation, provided that the treatment covers the whole of the affected tissue and an adequate margin beyond. In late cases the balance is weighed heavily against operation by the fact that irradiation of the affected tissues is neither difficult nor immediately dangerous, whereas excision involves a lengthy and complicated operation, which necessarily throws open the tissues of the neck to infection from the mouth. The only absolute indication for operation is involvement of the compact bone of the lower jaw. Involvement of its mucous covering may sometimes be cured by irradiation, but even with the strictest limitation of dosage the patient is not free from the risk of necrosis for many years after the treatment.

Any involvement of greater degree than this is not only incurable by irradiation, but also extremely unlikely to give a good palliative result.

The decision in cases showing extensive bone involvement is not difficult. Operation is the only chance of cure, or of reasonable prolongation of life, and its risks, which are admittedly high, must be faced.

At the other end of the scale are the cases in which involvement is limited to the soft tissues of the floor of the mouth, and in which there is no direct evidence of spread to the lymph glands of the neck. Such cases are eminently suitable for irradiation with or without a subsequent gland dissection, while operation (which must involve division of the jaw) is a measure of disproportionate severity. In this connection it is worth noting that attachment to the lower jaw may be much greater in appearance than it is in reality, and no growth should be written down as attached to the bone unless bimanual examination shows that attachment is undoubtedly present.

The most difficult cases are those in which the growth involves the floor of the mouth and shows evidence of direct spread to the tissues of the submaxillary triangle. In such circumstances the only operation which is of any value is a combined attack on the glands of the neck and the primary growth, a prolonged and complicated operation, which carries a mortality of between 40 and 50 per cent.* To hold out any prospect of success, this must be an *en bloc* removal of the affected part, with the jaw and the contents of the submaxillary triangle.

Irradiation is suitable for the buccal part of the growth, but in the great majority of cases it cannot be performed without affecting the tissues of the submaxillary triangle, and so rendering them unsuitable for the radical operation which offers by far the best chance of eradicating glandular metastases. In these circumstances no fixed rules can be laid down, but the surgeon will find that he is best guided by considering whether the case is one in which he is prepared to risk everything for a comparatively small chance of a permanent cure by operation, or whether he will serve the interests of the patient better by concentrating on the attainment of a reasonable palliative result by irradiation.

Cases which are doubtfully operable, either as regards the primary growth or the glands, are better treated by irradiation if it is available. A few such cases are permanently cured, and many more are kept alive and in comparative comfort for a limited period. Operation should be reserved for those in which the primary growth can certainly be removed intact, and the metastases, although they may be widespread, are still confined within the capsule of the glands. In such circumstances the results of operation are a fair reward for its risks.

For growths of the tongue which involve the floor of the mouth or the jaw, the available methods of approach are :—

(1) Horizontal division of the cheek.
(2) Median division of the jaw.
(3) Kocher's lateral submandibular approach.
(4) Lateral division of the jaw by Langenbeck's method.

(1) **Horizontal division of the cheek.**—This method, which is by far the best for mobile growths at the side of the tongue, can also be adapted to cases which show extensive bone involvement, and is very suitable for their removal when there is no demonstrable connection between the primary growth and the glandular metastases. The first stage of the operation consists of a preliminary tracheotomy and a radical dissection of the glands of the neck, according to the technique

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* Morrow : *Annals of Surg.*, 1937, cv, 418.

described on p. 1784. The external carotid artery is ligatured during the gland dissection.

At the second operation, which is undertaken as soon as healing of the neck wound is complete, the cheek is split from the angle of the mouth to the posterior border of the masseter (p. 1558), and the jaw, which can be exposed by turning down the lower flap, is divided in front of the growth. By retracting the masseter and the parotid, the ramus of the jaw is exposed, and can be divided well behind the growth. The posterior section can be carried as high as the neck of the jaw if necessary, and the isolated segment of the mandible, together with the affected part of the tongue and the tissues of the floor of the mouth connecting them, is removed. An attempt is made to close the internal wound by bringing the remains of the tongue across to meet the mucosa of the cheek on the affected side and, if necessary, tension is relieved by mattress sutures which are inserted through the tongue and passed so as to include the body of the lower jaw in their grip before being tied externally over rubber tubing. The wound in the cheek is repaired by the method described on p. 1558. The operation necessarily leaves a marked deformity, but it is better not to attempt any reconstructive measures until healing has been complete for several months.

This operation is designed for advanced cases, and the primary consideration is adequate removal of the growth. The second is prevention of serious infection by closure of the mucosa of the mouth and obliteration of dead spaces in which wound discharges might collect. If healing takes place satisfactorily, and at the end of six months there is no sign of recurrence, an attempt may be made to reconstruct the jaw by inserting a bone graft. Even without plastic repair some patients attain very tolerable function and appearance.

(2) **Median division of the jaw—Syme's method.**—This operation is most suitable for cases in which the growth has spread in the floor of the mouth without invading the compact bone of the lower jaw, and as it does not interfere greatly with swallowing, and the tissue planes of the neck are not widely opened up to infection from the mouth, the mortality is comparatively low. If it is thought that the excision will have to be extended posteriorly on the lateral wall of the pharynx, preliminary ligature of the external carotid is advisable; in other circumstances it is unnecessary.

The preliminary steps of the operation are described on p. 1559. After division of the jaw in the midline, its two halves are drawn apart by sharp hooks or strong thread ligatures. If there is obvious involvement of the submental glands, they must be excised in continuity with the growth; otherwise the fatty submental tissue is removed and the mylohyoid divided in the middle line. The mucous membrane to the outer side of the growth is divided from before backwards and, as the halves of the jaw are still further separated, the lingual and hypoglossal nerves come into view; after division of the hyoglossus, the lingual artery is exposed and ligatured. The posterior margin of the growth is now examined and, if necessary, the mucous membrane on the outer side of the tonsil is divided so that the tonsil and part of the lateral wall of the pharynx can be displaced inwards in continuity with the growth. The soft palate is sometimes involved by an extension along the anterior pillar and, if necessary, a part of it may be removed. The lateral wall of the pharynx is now divided behind the growth, and the operation completed by severing the muscles of the tongue from below upwards and inwards towards the dorsum.

The extent to which the wound can be closed depends on the posterior extension of the growth. It is not possible to cover in defects left by removal of portions of the lateral wall of the pharynx, but if the ulcer does not extend on to the tonsillar bed, the floor of the mouth can usually be closed by careful stitching from behind forwards, as the halves of the jaw are allowed to fall together. The rest of the wound is closed in the manner described on p. 1560, but if there is any doubt of the efficiency of repair of the mucosa, ample provision for drainage must be made. (Fig. 740.)

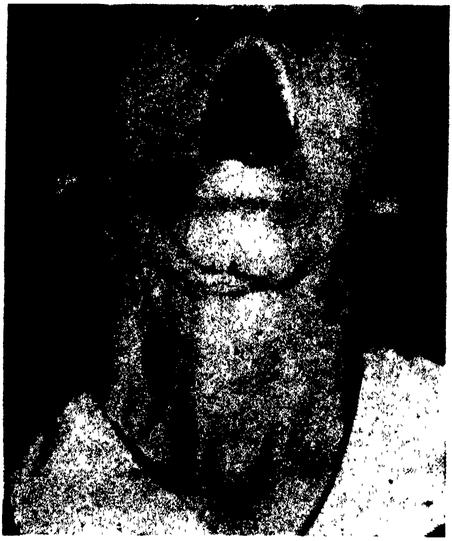

Fig. 740.--Late result, after ten years, of excision of the tongue by Syme's method. A radical gland dissection was also performed. The depression under the chin was caused by the extraction of a sequestrum from the midline of the jaw.

Kocher used a modification of this operation in which he divided the jaw to one side of the mid-line without freeing the soft parts from its posterior surface. This brings the plane of separation directly to the outer side of the geniohyoid, and the separation of the growth from its lateral attachments is achieved by drawing the tongue over to the sound side, together with the corresponding half of the jaw.

Kocher's method.—The operation more usually associated with Kocher's name is that of excision of the tongue from beneath the jaw after dissection of the submaxillary triangle. The early steps of the operation are identical with those described on p. 1568 as high lateral pharyngotomy. The operation has a high mortality and offers no special advantages in the treatment of growths on the lateral border of the tongue, unless there is direct continuity between the primary growth and infected submaxillary glands, without involvement of the jaw. In these circumstances Kocher's method may be tried. The chief danger of the operation is sepsis, and it is better not to attempt primary closure of the wound.

Lateral division of the jaw by Langenbeck's method.—This operation has been described on p. 1561. It has many objections, and its application should be restricted to the cases in which involvement of the jaw and deep penetration of the tissues of the submaxillary triangle make it inevitable.

Sulphonamide.—In all the operations it is wise to dust raw surfaces with sulphanilamide powder, and when the tissue planes of the neck are opened up they should be treated with sulphonamide before closure.

Irradiation.—Both interstitial and teleradiation have their uses in growths on the lateral border of the tongue. The interstitial method is preferable for growths in which the glands of the neck are either not enlarged, or are at a stage of involvement in which a radical dissection is likely to be successful. The object of the surgeon should be to secure the disappearance of the ulcer without impairing the nutrition of the tissues of the neck sufficiently to interfere with their reaction to the subsequent gland dissection. This object is much more easily attained if the needles are inserted from within the mouth rather than through the submaxillary triangle, and it is fortunate that the lateral part of the tongue and the floor of the mouth are sufficiently accessible to allow a uniform distribution.

Large growths which extend back on the lateral wall of the pharynx can seldom be properly exposed through the mouth, and never if marked trismus is present. In dealing with a case of this sort in which the glandular metastases are suitable for subsequent dissection, it is best to split the cheek and to use the increased access thus provided to ensure the accurate distribution of needles. The wound in the cheek is remote from the irradiated area, and its healing is not interfered with by the action of the radium. Such cases invariably require a preliminary tracheotomy.

The distribution of needles must be varied to suit individual cases. In a typical case, the free lateral border of the tongue is best irradiated by needles 3 to 6 cm. long, placed horizontally, and extending antero-posteriorly from ¾ cm. in front of the growth to the mucous membrane of the dorsum of the tongue behind. The floor of the mouth may be similarly treated, or short needles of 1 to 1½ cm. length may be inserted vertically in a plane parallel with the jaw. Extension towards the middle line of the tongue should be treated by a row of vertical needles about 2 cm. in length just beyond the visible margin of the growth.

Posterior extensions on the lateral wall of the pharynx can be dealt with by needles inserted horizontally between the mucosa and the ramus of the jaw, or through the anterior pillar of the fauces and the tonsillar bed. All these needles must be stitched in, and they must enter through normal mucous membrane, as the tissues of the growth itself are much too friable to hold them in place for the requisite 7 or 8 days. (Fig. 725, p. 1558.)

Teleradiation should not be used for the primary growth when the glands of the neck are to be dissected at a later stage. For cases which show metastases that are inoperable by reason of their fixity or their wide distribution, teleradiation is the method of choice, and although the results for prolonged survival are disappointing, many excellent palliative results are obtained. Growths in the lateral border of the tongue which metastasize widely are occasionally of the lympho-epitheliomatous type, which is commoner in the posterior third, and reacts much more rapidly and certainly to irradiation. Metastases of the common type of well-differentiated growth are very seldom cured, but are often much improved. Teleradiation is the best method for cases of this sort, as it allows simultaneous treatment of the primary growth and the glandular metastases without the introduction of sepsis, but where large quantities of radium, and the necessary experience in their use, are not available, interstitial irradiation should be used.

Growths of the posterior third of the tongue.—Many of these growths are lympho-epitheliomata. No growth recognized as belonging to this group should ever be submitted to operation, as any form of mass-irradiation will ensure disappearance of both primary growth and metastases. Distant irradiation with the radium bomb is probably the most efficient means of attack, but deep X-ray therapy is very nearly as good. In the absence of either of these, both primary growth and glands should be treated by interstitial irradiation.

Unfortunately many of these tumours recur in parts of the body remote from the primary lesion, so the five-year survival rate is not high. The site of the primary growth and that of the immediate metastases often remain free from recurrence until the end, and at the time when these patients die it may be impossible to say from examination where the primary lesion lay.

Squamous carcinomata occur in the posterior third of the tongue, although they are rarer than the lympho-epitheliomata. They are generally recognizable clinically by their earlier ulceration and the hardness and fixity of their metastases. For them the general rule holds good that if the primary growth and the metastases are not obviously connected their treatment should be considered separately. Interstitial irradiation for the primary growth and dissection of the affected glands is the best treatment.

Preliminary tracheotomy should be carefully considered before the irradiation is carried out, remembering that insertion of needles in the posterior third of the tongue may produce œdema round the upper opening of the larynx, either immediately, or after the lapse of several days.

The technique of irradiation is not difficult provided that the surgeon bears in mind the shape and dimensions of the tongue. The tongue is drawn out of the widely open mouth (there is, as a rule, no trismus) and the palpable margins of the growth determined. Needles from 2 to 4 cm. in length are required, and are best inserted from above downwards and stitched into place as shown in Fig. 724, p. 1552. With one finger in the mouth and the other in the hyoid region, it is not difficult to estimate the thickness and extent of the tissue to be irradiated. In a typical case the anterior row of needle punctures should be convex forwards in conformity with the shape of the hyoid bone and, as a rule, only two or three more are required in the thick median part of the tongue behind these.

If there is difficulty in inserting the posterior needles from the mouth, they may, without prejudicing the subsequent gland dissection, be inserted through the skin of the neck in the hyoid region, while their direction and position in relation to the growth is controlled by a finger in the mouth.

Many growths of the posterior third affect the glands on both sides of the neck and, if there is doubt of the patient's ability to stand a bilateral dissection, or if the glands are so advanced as to put in question the possibility of a radical removal, teleradiation should be used in place of the interstitial method. The base of the tongue is rather better situated for this form of treatment than the lateral border and, although very few cures will be obtained in cases with squamous growth in the glands, good palliative results may be expected.

Operation.—The value of operation is more questionable in the posterior third of the tongue than anywhere else in the mouth. It has already been stated that lympho-epitheliomatous growths are totally unsuited to operative methods. Of the squamous growths there is a small group which are accessible by Trotter's method of median division of the jaw and tongue. For growths which are limited to the centre of the base of the tongue in the epiglottic region, this method gives an excellent exposure and allows excision with an adequate margin without undue risk of sepsis. The preliminary steps of the operation are described on p. 1562. When the median incision comes within range of the growth, excision is begun by cutting outwards on either side. " As soon as the growth has been separated from the tongue it can be drawn upwards into the wound, the aryepiglottic folds divided, and a horizontal cut made across the epiglottis just above the vocal cords. The growth is now free from everything but the body of the hyoid bone, and all that remains is to disarticulate the latter from the great cornu on each side. Neither of the lingual arteries is as a rule seen or divided. The large gap left by removal of the growth is closed by sutures which draw the parts together in the mid-line. This manœuvre is rendered easier by the absence of the body of the hyoid bone. The two halves of the tongue are then stitched along the dorsal and ventral surfaces and, after uniting the separated halves of the jaw, the lip is repaired and drainage established in the submental region." (Trotter.)

This operation is relatively free from septic complications and does not interfere with a subsequent gland dissection. Even in cases which are unlikely, from the presence of metastases, to provide a permanent success, the operation is justifiable as it gives a good palliative result without undue risk. Unfortunately, it is not applicable to growths which affect the lateral part of the base of the tongue. In this case the only available operations are lateral division of the jaw combined with a partial or complete dissection of the deep cervical glands (*see* p. 1561), or a high lateral pharyngotomy. Both are operations of great severity, and carry a high mortality in patients who are already debilitated as a result of the presence of a growth.

THE POST-OPERATIVE PERIOD

Immediate shock.—This complication is often encountered after extensive operations in the mouth and neck, but seldom after irradiation. It occurs much less in patients whose general condition before operation is good, and its incidence may be diminished by paying careful attention to preliminary treatment. Adequate nourishment in the pre-operative period is essential and, if the patient is unable to swallow in comfort, gastrostomy should be done. Physical and mental comfort are most important, and no patient should be operated on until he has had time to settle comfortably in his surroundings.

During the operation gentleness in manipulation is more important than speed, provided the anæsthesia is satisfactory. If, on the other hand, breathing is difficult and the patient is persistently cyanosed, every effort must be made to reduce the duration. The relation between shock and sepsis is an interesting one. It will often be found that the patient who suffers severely from shock is the one who ultimately develops signs of well-marked sepsis, and it is possible that the release of organisms into the blood stream at the time of operation provokes, or at least increases the shock in many cases. The dangers of shock itself are only immediate, but patients who have suffered from it are more liable to later complications than those who have not.

Sepsis.—Sepsis is a cause of anxiety in all buccal operations, and, when it is necessary to open up the planes of the neck to infection from the mouth, it is a frequent cause of death. Its avoidance is partly a matter of preliminary treatment, and partly of faultless operative technique, but however careful the surgeon is, sepsis of some degree is very common. It becomes a serious complication when it spreads beyond the neck or when it provokes a secondary hæmorrhage. Both these complications are less likely if free drainage is provided, and accordingly no neck wound should be tightly sutured if infection is anticipated.

The dangers of spreading sepsis can now be much diminished by the use of sulphonamides.

Pulmonary complications.—Together with sepsis, pulmonary complications account for practically the whole of the mortality after operations on the tongue and mouth. They are less frequent after interstitial irradiation, but by no means negligible. Much may be done to prevent them by the exercise of care and forethought in the pre-operative period, and during the operation the avoidance of the inhalation of discharges from the growth is of the greatest importance. In spite of the exercise of every care and precaution, the pulmonary morbidity and mortality remain very high in this class of case.

Local care of the wound.—External wounds in the neck should not be covered with bulky dressings, which are apt to become sodden with decomposing discharges. They should be kept as dry as possible and covered with a light dressing which is frequently changed if there is any suggestion of sepsis.

The wound of the mucous membrane is usually more or less inaccessible, and obscured by œdema. It is best treated by frequent syringing, which the patient can soon be taught to do for himself by holding the head forward over a basin while he directs a stream of lotion over the wound from a Higginson's syringe. Mopping the wound does not do much good except for the removal of decomposing blood clot, and later on of sloughs. If gauze plugs have been used, they should be removed within the first few days. If this is not done, they may set into a mass so hard and impervious to pus that it is forced to spread in less favourable directions.

Feeding.—It is of the greatest importance to ensure that patients in the post-operative period are properly fed. Many of them are old and have little reserve of strength, and if every feed is an ordeal to be dreaded the intake very soon becomes limited, and the patient rapidly begins to lose strength and heart. The value of preliminary gastrostomy from this point of view can hardly be over-estimated, but this operation is only required when the growth is extensive and so situated that its removal interferes with comfortable swallowing. The difficulties in swallowing after the removal of smaller growths can be overcome by the use of a feeding cup to the spout of which a rubber tube has been attached, so that fluids can be delivered directly into the upper part of the pharynx.

THE TREATMENT OF LOCAL RECURRENCES

(1) After irradiation.—A distinction must be made between recurrences in the centre of the treated area and its periphery. A recurrence of growth in the centre of tissue which has been adequately treated means that there is little difference between the sensitivity of the growth and that of its surroundings, and that further irradiation is as likely to cause necrosis of the normal tissues as regression of the growth. Thus, recurrences of this type may be treated by excision or diathermy, but never by irradiation. Recurrences at the periphery of a treated area when the centre remains healed suggest that the original irradiation was too circumscribed, and that a portion of the extending edge has been missed. Such recurrences may be treated by irradiation with every expectation of their reacting in the same way as the original growth.

(2) After operation.—Recurrences in the mouth after operative removal of carcinomata are often difficult to deal with by excision. The amount of normal tissue which can be removed with the recurrence is strictly limited and, owing to the induration of the scar tissue, it is often very difficult to be sure how wide an excision is desirable. Post-operative recurrences in the mouth are, therefore, generally better dealt with by irradiation on the principles which have been described for primary growths. In the neck, where the operator is less restricted in the extent of normal tissue which he can excise, irradiation presents no advantages over operation, unless essential structures which cannot be removed are involved.

SEPARATE TREATMENT OF GLANDULAR AREAS

In those cases in which the glands of the neck are involved and it is decided to treat them separately from the primary growth, operation remains the most efficient method, provided that the growth is of a well-differentiated type and has not extended beyond the capsule of the glands. To be successful, operation must be very thorough, and in nearly all cases it is best to perform a complete block dissection, removing both the sternomastoid and the contents of the submaxillary triangle, though in a few cases of carcinoma of the lip a more limited bilateral operation is justifiable. Gland dissection is best performed after the primary lesion has been treated, but in cases requiring preliminary control of the circulation this order must be reversed.

Cases in which the clinical characteristics or microscopic appearances of the primary growth have shown it to be of the undifferentiated or lympho-epitheliomatous type, are unsuitable for operation and should be treated by teleradiation or deep X-ray therapy. Even in squamous growths, the results of non-radical operations are disastrous. Metastases which have appeared very rapidly, or which are disproportionate in extent to the primary lesion, are very seldom curable by dissection and should, if possible, be treated by teleradiation which, although it provides few cures, does at least avoid diffuse recurrence in the tissues of the neck. Extensive secondary deposits which are fixed to the great vessels or to the prevertebral fascia are also unsuitable for operative removal; teleradiation is the most suitable treatment, but is only palliative.

When there is no palpable enlargement of the glands the correct treatment depends on the size and the extent of the primary lesion. There is no doubt that growths occur in all parts of the mouth which have little tendency to spread to the glands of the neck, but there is at present no means of distinguishing them with certainty from the others. The situation of the growth is more helpful than any other single characteristic. When it is in the tongue, operation should be advised in all cases and, if the growth approaches within a centimetre of the middle line, bilateral dissection in two stages increases the chance of success.

in other situations the position is different. Many patients with small epitheliomas of the lip and no obvious enlargement of the glands remain permanently well if the primary lesion only is treated and, provided that the patient can be kept under regular and frequent observation, it is justifiable to leave the glandular areas untreated. A few cases of carcinoma of the lip treated on these lines develop metastases but, provided that they are examined at intervals of not more than three months, the chances of cure are probably not materially affected by the delay. A larger proportion do not develop metastases and these are spared the danger and discomfort of an unnecessary gland dissection.

Growths of the cheek and the floor of the mouth or the mucous membrane of the alveoli have less tendency to glandular metastasis than the tongue and more than the lip, and in them dissection should be undertaken in all cases in which the primary growth is extensive or of long standing.

When the primary lesion affects the bone of either jaw, the prospect of local recurrence is so high that it is better to wait six months or so after treating the primary lesion and to perform a gland dissection only if there is a reasonable prospect of freedom from local recurrence.

Prophylactic irradiation of glandular areas which show no clinical evidence of involvement is of very doubtful value, and I have completely abandoned it. Growths in all situations may give rise to some glandular enlargement as a result of sepsis, and glands which are palpable but not obviously carcinomatous are always a source of anxiety. I attach little significance to palpability as an indication of the likelihood of invasion as long as the ulcer of a primary growth is present. If such glands persist after the primary growth has been cured, it is better to assume that they are infiltrated with carcinoma and to treat them accordingly.

Prognosis of Carcinoma of the Mouth and Tongue

The outlook in these cases depends on the type of growth and the tendency to metastases, as well as the stage of advancement at the time when the patient first seeks advice. The most reliable indication is the site, and by considering this in conjunction with the clinical characteristics and the presence or absence of obviously infected glands, a reasonably accurate estimate can be made of the chances of cure. A short history is by no means always a favourable point in the prognosis, as patients suffering from rapidly growing and highly malignant lesions come for treatment earlier than those with more chronic types of growth. Lesions which are infiltrating and non-ulcerating can generally be kept in check for years by irradiation, but they practically always lead ultimately to death. An ulcerating growth which is mobile has a better prognosis than a similar one in which induration is present in the surrounding tissues.

Estimation of prognosis by the microscopic structure of the primary growth is helpful up to a point, for the surgeon knows that practically all highly anaplastic growths have metastasized to the glands by the time the patient comes for treatment, whereas if the growth is well-differentiated and localized, there is a good chance that the glands are not involved.

Direct evidence of glandular involvement, whatever may be the site and structure of the primary growth, reduces the chances of a five-year cure by at least 50 per cent. and, if the primary growth is small and of recent appearance, the presence of invaded glands means that the case is practically hopeless. Age has no great influence on prognosis, but on the whole growths occurring in young people are more malignant than those which appear in later life.

Prognosis according to the site of the primary growth.—**The tongue.**—An unselected series of cases of carcinoma of the tongue treated by any efficient method may be expected to show a five-year survival rate of about 20 per cent. By eliminating advanced cases this figure may be improved to some extent, but Butlin's 42 per cent. of five-year cures has never been surpassed, and this may be taken as about the highest percentage attainable by rigid selection and energetic treatment. A special point in estimating the prognosis in carcinoma of the tongue is the presence of syphilitic infection. Carcinoma in a tongue which shows gross evidence of syphilitic infection is much more difficult to treat, and carries a much worse prognosis than a similar lesion occurring in an otherwise normal tongue.

The lip.—Carcinoma of the lip is a comparatively benign lesion, and a series of cases in which the glands are not obviously involved at the time of treatment may show a five-year survival rate of 90 per cent. or even more. Cases with obviously involved glands show a survival rate of 30 per cent. to 40 per cent. five years after treatment.

The floor of the mouth.—There are no available figures for large series of carcinomata in this situation. They are certainly more favourable than growths of the tongue, and less so than those of the lip. A small series of personal cases shows a five-year survival rate of 75 per cent., but the figure would probably be considerably lower in a larger series.

The cheek.—There is some difference of opinion regarding the malignancy of these growths. In my experience they are comparatively benign, and such figures as are available indicate that when the growth is seen and treated in its early stages a five-year cure may be expected in well over 50 per cent. of cases. Advanced growths in this situation have a very bad prognosis.

Growths involving the jaws and alveoli.—Several different types of growth occur in this situation, and they are not sufficiently classified in any published figures to give much idea of the prognosis of any one type. It is certain that growths which infiltrate the lower jaw widely are practically hopeless from the outset. Those which extend widely in and around the upper jaw can generally be improved by irradiation, but few of them survive as long as five years. Localized papillary growths of the alveolus have a better prognosis provided they have not destroyed the bone widely, and in them the five-year survival rate is probably about the same as it is in carcinoma of the tongue.

DISEASES OF THE SALIVARY GLANDS

Anatomical and Physiological Considerations

The parotid gland.—The greater part of the parotid gland lies superficially on the ascending ramus of the mandible, and between it and the mastoid process. Above, it reaches to the zygoma and below it ends about the level of the angle of the jaw, behind which it comes practically in contact with the posterior end of the submaxillary gland. Its lower and posterior part overlaps the sternomastoid to a variable extent, and from its upper and anterior part a process runs forward across the masseter in company with the duct. The deeper part of the gland is irregular in shape, and passes inwards between the ascending ramus of the jaw and the mastoid process towards the lateral wall of the pharynx. The glandular substance extends on either side of the styloid process, and is in contact on its deep surface with the internal carotid artery and the jugular vein. The external carotid artery traverses the substance of the gland, and its two terminal branches are intimately related to it. The large veins corresponding with the internal maxillary and superficial temporal arteries unite within the gland substance to form the posterior facial vein, and a branch passes anteriorly in the substance of the gland to join the anterior facial vein. There are numerous smaller veins in the gland substance, many of which are large enough to cause bleeding sufficient to embarrass the operator.

The facial nerve enters the posterior part of the gland after leaving the stylomastoid foramen and divides into its branches of distribution posterior to the ramus of the mandible. The branches run in the superficial part of the gland and leave it at various points on its anterior margin. The whole gland is enclosed and supported by a very firm unyielding fibrous capsule.

The parotid duct runs from the upper anterior part of the gland across the superficial surface of the masseter muscle. At the anterior border of the muscle it turns sharply inwards, and pierces the buccinator and, after running obliquely between the muscle and the mucous membrane for a short distance, it opens into the mouth just opposite the second upper molar tooth. The course of the duct is indicated on the surface of the cheek by a line running from the lower border of the incisura intertragica to a point midway between the columella of the nose and the red margin of the lip.

At least one lymph gland lies within the capsule of the parotid in intimate association with the glandular substance.

The submaxillary gland.—The submaxillary gland occupies practically the whole of the submaxillary triangle of the neck, and overlaps its lower boundary by half-an-inch or more. It consists of a superficial portion which is enclosed in a firm capsule and lies on the surface of the mylohyoid, and a deep portion which lies deep to this muscle on the hyoglossus and immediately beneath the mucous membrane of the floor of the mouth. The duct accompanies the deep portion of the gland and opens on a small papilla just to one side of the frænum linguæ. The facial artery is imbedded in the posterior part of the submaxillary, and must generally be sacrificed when the gland is removed. A number of lymph glands belonging to the submaxillary group lie within the capsule, and nodules of lymphatic tissue are sometimes found imbedded in the salivary tissue.

The relation of the lingual nerve to the submaxillary gland is of considerable importance. It lies on the surface of the hyoglossus, about ¼ in. above the deep part of the gland, and runs roughly parallel with the duct. The nerve is connected with the gland by the submaxillary ganglion, and when the parts are matted together by inflammatory adhesions, it is by no means easy to separate them. Injuries of the lingual nerve have frequently occurred during excision of the gland and, as division of the nerve leads to unilateral anæsthesia of the tongue, it is a serious accident. (See Fig. 743, p. 1603.)

The sublingual gland.—This small gland lies beneath the mucous membrane of the floor of the mouth between the frænum linguæ and the body of the mandible. It delivers its secretion into the mouth by a large number of small ducts, some of which open along the plica sublingualis, while others are in close relation with or actually joined to the submaxillary duct.

Physiology.—The secreting cells of the salivary glands are of two types, one producing a serous and the other a mucous fluid. The secretion of the parotid gland is purely serous, and that of the sublingual purely mucous. In the submaxillary gland alveoli of both sorts are found, and the secretion is mixed. Probably as a result of this, stones or concretions composed of the solid constituents of saliva are found much more commonly in the submaxillary gland than in either of the others. Parotid stones are seen occasionally, but sublingual stones are a rarity. The results of disease or extirpation of the salivary glands also differ according to the nature of the secretion. One or even both submaxillary glands can be removed without producing any symptoms, but if the secreting power of one parotid is interfered with by chronic inflammatory disease, or abolished by irradiation, the patient always complains of dryness of the mouth on that side. Absence of parotid secretion on both sides constitutes a serious disability.

Internal secretion.—The question of the production of an internal secretion by these glands has recently been raised, but it does not appear that their function in this direction is of any real importance.

INJURIES AND FISTULÆ

Wounds of the gland substance may discharge a little saliva for a time, but they seldom fail to heal spontaneously, and no special treatment is required for them as a rule. If they fail to heal, scraping the granulating surface associated with them may be tried. Fistulæ of the gland substance which persist in spite of this treatment are best treated in the submaxillary by excision of the gland, and in the parotid by arresting secretion by external irradiation.

Wounds of the parotid duct should be directly sutured if they are seen at once, and the operation may well be successful, even when there is complete transverse division. Repair is aided by the introduction of a fine tube, such as a ureteric catheter, and sutures should be introduced through the tissues surrounding the duct rather than the duct itself. The skin wound should not be closed too tightly for fear of infection.

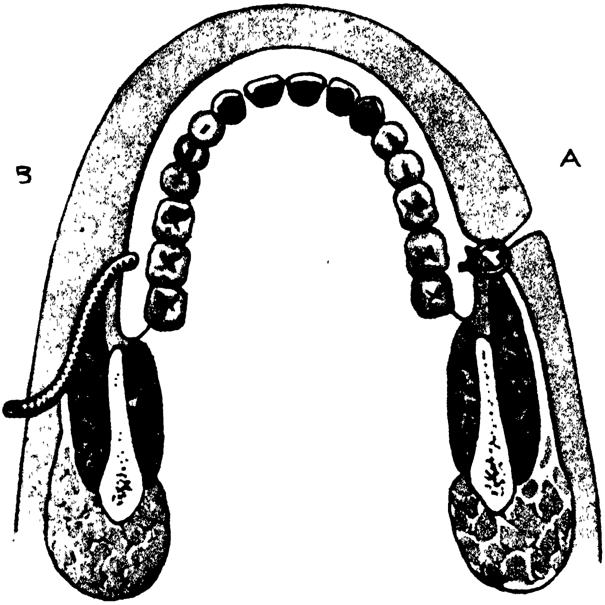

Fig. 741.—Diagram of operations for fistula of Stenson's duct.
A, premasseteric portion ; B, masseteric portion. (*From Choyce : System of Surgery.*)

On the left side a needle carrying a strong silk thread was passed through the fistula into the mouth in front of the masseter and used to draw the fine rubber tube into the position shown. When a track has been established, the tube must be withdrawn into the mouth by stages, taking about a week to complete the process. The external fistula may then close spontaneously or may require a plastic intervention.

Internal fistulæ of the parotid produce no symptoms and require no active treatment. External fistulæ are extremely trying to the patient, and an attempt should always be made to cure them. If the fistulous opening is not too far back, the simplest method is to induce the formation of an internal fistula in the place of the external one. This can be done by inserting a ligature of strong thread or wire so as to include a piece of tissue between the remaining part of the duct and the oral mucosa. This ligature is tightened so that the included tissue ultimately necroses and leaves a free communication between the duct and the mouth. After the ligature has separated, the margins of the skin opening may be freshened, if necessary, and united so as to accelerate healing. (Fig. 741).

The artificial track between the duct and the mouth should not pass through the masseter, and the operation may be inapplicable when the fistula lies very near the origin of the parotid duct. Various plastic operations have been designed for use in these circumstances, but it is far simpler and more satisfactory to destroy the secreting cells of the gland by irradiation and leave the opening to heal spontaneously.

External fistulæ of the submaxillary gland are extremely rare. They should be treated by excision of the gland. Internal fistulæ in the floor of the mouth result occasionally from ulceration of stones into the mouth from the duct or incisions for their removal, but they cause no symptoms and do not require treatment.

INFLAMMATORY DISEASES

Acute inflammation of the parotid gland was at one time a much dreaded complication of abdominal operations. Since the importance of frequent cleansing of the mouth has been understood, the complication has become very rare, but is still occasionally seen. It nearly always occurs in patients whose general condition is poor, and the prognosis is bad. Post-operative parotitis nearly always leads to suppuration, but the external signs of pus formation are late in appearing owing to the thickness of the parotid capsule.

Incision of parotid abscess.—If operation is delayed too long the abscess may burst through the lower end of the capsule and track beneath the sternomastoid towards the mediastinum, with serious results, so that the surgeon is well advised not to wait for fluctuation before making an incision. Transverse incisions, which are often advised as a means of avoiding damage to the facial nerve, do not give very satisfactory drainage, and it is better to incise the capsule vertically. If the incision is made in the extreme posterior part, just in front of the lobe of the ear, and is not carried deeply into the substance of the gland, there is no danger of injury to the nerve, but if pus is not found immediately beneath the capsule the search for it should be pursued with sinus forceps.

Parotid abscesses which are incised by this method drain well, and the resulting scar is hardly noticeable. In some cases, instead of a localized abscess, there is a diffuse purulent infiltration of the gland. In these circumstances the lower end of the incision is turned forward just below the jaw as far as the anterior border of the masseter and the flap of skin so demarcated is raised so as to expose practically the whole of the surface of the parotid. Several transverse incisions are then made through the capsule in the line of the branches of the facial nerves, and the gland substance is opened up by sinus forceps. (Fig. 742.)

It is worth noting that a subperiosteal abscess of the ascending ramus of the jaw gives physical signs practically identical with those of parotid abscess, and if pus is not discovered within the capsule a search should always be made deep to it at the level of the outer surface of the bone.

Salivary calculi.—Calculi are rare in the parotid gland but are occasionally seen in the duct, where they are palpable from the mouth. If they do not pass spontaneously, the orifice of the duct should be enlarged by dilatation or incision. Even if the calculus cannot be extracted at once after this procedure, it nearly always passes spontaneously within a few days.

A few cases of calculi in the substance of the parotid gland are on record and, in view of the difficulty of relieving this condition by surgical means, it is worth noting that Bsteh records* a case in which a patient suffering from bilateral multiple parotid calculi complicated by severe infection was completely relieved by the use of external irradiation.

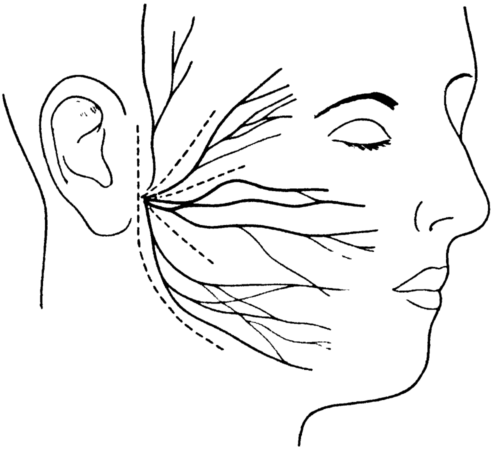

Fig. 742.—The dotted lines show the positions in which the surface of the parotid gland may safely be incised for evacuation of pus or removal of innocent tumours. The branches of the facial nerve are shown as continuous lines.

Submaxillary calculi.—Submaxillary calculi may occur in any part of the duct, or in the substance of the gland itself. They may become impacted just behind the orifice of the duct, and if they cause ulceration of the mucous membrane in this situation, they are easily mistaken for carcinoma of the floor of the mouth. A stone in this situation can be extracted without difficulty by making an incision in the mucous membrane over it, the wound being left unsutured.

More commonly, stones are found farther back in the duct, in the region of the anterior molar or posterior premolar tooth. These stones should also be extracted through the mouth but, unless the operation is undertaken deliberately and in favourable surroundings, it may be very difficult. General anæsthesia is preferable, as the œdema produced by local infiltration may make it difficult to locate the stone. A stitch should be inserted deeply behind the stone to prevent it from slipping backwards and, after localizing the exact position, a longitudinal incision should be made in the line of the duct over the site of impaction. This is most easily done with a diathermy needle passed, before the current is turned on, into the tissues of the floor of the mouth, until it is felt to touch the stone. With the current in operation, the needle is lifted outwards, so that the tissues overlying the stone are cleanly divided, and as there is no bleeding the stone can easily be seen and extracted. Performed in this way, the operation only takes a few minutes, but if it is carelessly done, and the incision is made before the position of impaction is exactly localized, the field becomes obscured by blood and the operator may have considerable difficulty in finding the stone.

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* *Zentralbl. f. Chir.*, 1932, lix, 2931.

It occasionally happens that a stone which is not impacted causes dilatation of the duct. The stone in this case is usually small and freely mobile, and in consequence cannot be felt with certainty through the mucous membrane. In these circumstances it is better to expose and open the duct and search for the stone from within. In doing this it must be remembered that the duct lies on the hyoglossus, and the incision for its exposure must be made only a little outside the line along which the mucosa of the floor of the mouth is reflected on to the under surface of the tongue.

Wounds resulting from the removal of stones in the submaxillary duct should always be left open, as infection is very often present and suture may lead to spreading sepsis in the tissues of the floor of the mouth.

A most difficult decision faces the operator when the stone is impacted far back in the commencement of the duct. In this position it can be felt and extracted through the mouth in the same way as one which is impacted more anteriorly, but as infection is nearly always present, and the gland itself is enlarged, extraction of the stone does not always relieve the symptoms. In cases of this type New and Harper * found that recurrence of symptoms took place in 23 per cent. of patients, as compared with 13 per cent. when the stone was impacted anteriorly.

If the gland is not obviously enlarged to external palpation, it is right to try the effect of removing the calculus through the mouth. If the gland is considerably enlarged, it is wise to explain matters to the patient, and if he or she is anxious to avoid an external scar, the calculus may be removed locally, but only on the understanding that subsequent removal of the gland may be necessary. If early and complete relief of symptoms is the primary consideration, removal of the whole gland through the neck is preferable.

When the gland is severely infected and grossly enlarged, or when calculi are present in it which cannot be felt from the mouth, there is no doubt that the gland should be completely removed through an external incision. The operation is not technically easy on account of the widespread inflammatory fibrosis and œdema which surround an infected gland, but the late results are excellent.

Removal of submaxillary gland.—The incision should start one inch behind the anterior border of the sternomastoid, and about two inches below the tip of the mastoid process and, curving downwards in its middle nearly to the hyoid, should extend anteriorly to about one inch behind and below the symphysis menti. It is important not to carry it up between the sternomastoid and the angle of the jaw, as this nearly always produces a partial paralysis of the lower lip. The incision is deepened at once through the superficial fascia and the platysma, and the flap so formed is turned upwards until the lower border of the jaw is exposed. The facial vessels are divided where they cross the mandible, and the upper border of the submaxillary gland is freed in its whole extent.

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* *Surg. Gyn. & Obst.*, 1931, liii, 456.

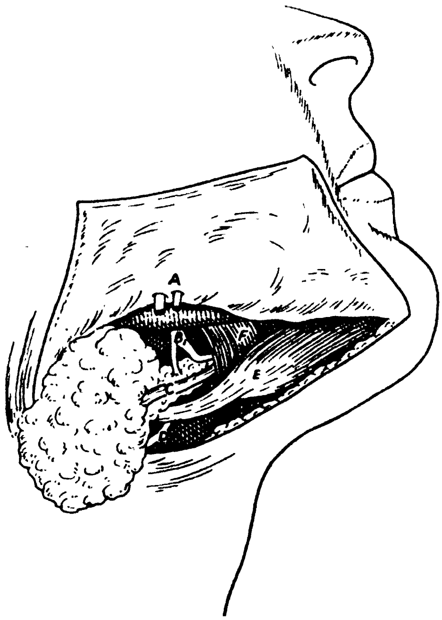

Fig. 743.—Excision of submaxillary salivary gland. The superficial part has been freed from the lower border of the jaw and the mylohyoid and turned back over the posterior belly of the digastric.

A, facial vessels divided where they cross the jaw. B, lingual nerve. C, duct of submaxillary gland and deep part of gland. D, hypoglossal nerve. E, digastric muscle —anterior belly. F, mylohyoid.

Turning to the posterior extremity of the gland, the common facial vein is divided and, working between the gland and the anterior border of the sternomastoid, the facial artery is defined and ligatured close to its origin from the external carotid (Fig. 743.) It is now best to turn to the anterior part of the wound and free the superficial part of the submaxillary from the mylohyoid, so that on retracting this muscle the gland is left attached by its deep part and its duct only. These are traced across the outer surface of the hyoglossus and carefully separated above from the lingual nerve before the duct is divided. The remains of the deep part of the gland should be tied like a pedicle. There is usually a fair amount of bleeding and drainage is necessary.

Tumours of the Salivary Glands

New growths, which are generally referred to as mixed or salivary tumours, occur fairly commonly in the lower part of the parotid and occasionally in the submaxillary gland. Judged by their clinical characteristics, these tumours are typically innocent, for they are sharply defined and completely encapsulated. The after-history of operated cases throws some doubt on their innocence, and in dealing with them the surgeon should keep in mind that the recurrence rate after operation is extremely high (45 per cent. in some collected figures) and that post-operative recurrences generally grow more rapidly than the primary tumour and are often frankly malignant. The frequency of recurrence suggests either that a high proportion of apparently innocent tumours have already undergone malignant degeneration before operation, or that outlying portions of the tumour are frequently overlooked, and so escape removal. It follows that meticulous care must be taken in enucleating the irregular extensions of outlying parts of the growth, and as an additional measure of safety many surgeons prefer to use some form of irradiation as an adjunct to surgical treatment.

Operation for removal of encapsuled tumours.—Preliminary external irradiation is sometimes used. It is said to facilitate excision by producing a small amount of œdema round the capsule, and to reduce the risk of implanting active tumour cells in the wound. Local anæsthesia reduces venous bleeding, and makes identification of branches of the facial nerve less difficult.

Incision.—Small tumours are generally approached through a transverse incision which runs parallel with the main branches of the facial nerve. Large tumours which require a wider exposure are best approached by an incision which starts immediately in front of the external auditory meatus and, after following the posterior border of the jaw as far as its angle, turns forward, a finger's breadth below the horizontal ramus, as far as the anterior border of the masseter. When the flap of skin so marked out is raised, a wide exposure of the surface of the gland is obtained and, although a temporary droop of the lower lip sometimes follows (possibly as a result of paralysis of the platysma), no permanent facial weakness need be feared. The surface of the tumour is exposed by incising the capsule transversely (Fig. 742), and thereafter dissection is pursued with extreme care, so as to make sure that no branches of the facial nerve are injured. Small tumours can generally be shelled out intact by a combination of blunt and sharp dissection, but the capsule of the tumour is often extremely thin and the substance may be very soft, so that the slightest roughness in traction, or even the use of toothed forceps to grasp the tumour, may rupture the capsule and contaminate the raw tissues of the wound with tumour substance. Large tumours often lie completely superficial to the facial nerve and its branches, and can be removed in the same way. If the surgeon feels that, owing to the size and complicated extensions of the tumour, he is in danger of leaving portions behind, he may consider proceeding by the method of Hybinette, who deliberately incises the tumour on its superficial aspect and, after squeezing out the substance, completes removal of the capsule by working with his finger inside it. This method should, of course, only be employed after all possible precautions have been taken to protect the raw tissues of the wound from contamination, and it should never be used if there is any suspicion of malignancy.

In view of the high recurrence rate, and the difficulty of deciding either by clinical or microscopic evidence whether a particular tumour has retained its innocent characteristics up to the time of operation, many surgeons prefer to employ some form of post-operative irradiation as a routine. Either X-rays or teleradiation may be used after the wound has healed. Alternatively, radium needles may be inserted round the tumour bed at the time of operation, but they should never be placed actually in the cavity left by the removal of the tumour, as this practice nearly always delays healing, which may be very prolonged. If the interstitial method is used, it is best to insert the needles in a plane as nearly as possible at right angles to the surface, and about half a centimetre outside the actual tumour bed. If needles of the type described on p. 1551 are used, they should be inserted about one centimetre from one another and left in position for seven or eight days.

Innocent tumours in connection with the submaxillary gland are best treated by excision of the whole gland, unless they are very superficial and easily defined. The operation is not followed by disability and ensures complete freedom from recurrence.

Malignant tumours of the salivary glands.—The parotid is affected much more often than the submaxillary. Carcinoma of the parotid appears sometimes as a superficial growth involving the lower part of the gland and producing early ulceration, but more often as a deep infiltrating tumour. A considerable proportion of infiltrating tumours arise either in an encapsulated tumour or in the site of one which has been treated by excision.

Excision of malignant parotid tumours.—The results of pure surgical treatment are bad, and statistics mostly show a five-year survival rate of well under 20 per cent. The prognosis is better in superficial growths than in those which spread deeply.

Excision must be carried out regardless of interference with surrounding structures and, unless the tumour is very small and superficial, total extirpation of the gland must be aimed at. Removal of a certain amount of skin when the tumour approaches close to it is no disadvantage, and may make the facial paralysis (which inevitably results from the operation) less noticeable ; but for deep tumours a flap hinging posteriorly may be used. Complete excision of the gland is very difficult to achieve, and can only be attempted after ligature of the external carotid and excision of the condyle of the jaw, together with a part or the whole of the ascending ramus. The facial nerve is necessarily sacrificed, and the dissection must be carried deeply as far as the internal carotid artery and the lateral wall of the pharynx.

Treatment of malignant parotid tumours by irradiation.—Some malignant salivary tumours are radiosensitive. According to Ahlbom,* about 58 per cent. show some degree of radiosensitivity, and in 16 per cent. the sensitivity is marked. He attempts to relate these characteristics with the histological structure, and comes to the conclusion that most of the radio-resistant growths are of the squamous-celled and adenocarcinoma type. As elsewhere, growths which increase rapidly in size and generally appear highly malignant react better to irradiation than those of a more benign type.

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* *Act. Rad. Suppl.*, 1935, No. 23.

Irradiation, if it is available, should always be tried before operation is undertaken for a malignant parotid tumour. If it is of a highly sensitive type the tumour begins to diminish in size within a few days of the commencement of the treatment, and complete disappearance may be expected in four to eight weeks. Facial paralysis due to the pressure of the tumour may recover completely.

Technique of irradiation.—External irradiation appears to give good results at Radiumhemmet, but the interstitial method according to the principles suggested on p. 1550 is also perfectly satisfactory. The actual distribution of the needles depends on the size and shape of the tumour, but in most cases it will be found convenient to insert them at right angles to the plane of the skin surface.

A combination of radiological and surgical methods has been extensively tried at Radiumhemmet but, allowing for the fact that the combined treatment group necessarily consisted of operable cases while 74 per cent. of the radiotherapy group were inoperable, surgery as an adjunct to irradiation does not appear to produce any significant increase in the recovery rate. Five-year cures are obtainable by irradiation in about 50 per cent. of operable cases, and 23 per cent. of a complete series.

It therefore appears that the correct treatment for malignant tumours of the parotid gland is to try the effect of irradiation in all cases. If the tumour shows that it is markedly sensitive no other treatment should be employed. If it fails to react, surgery may be tried.

Treatment of the glandular areas.—Glandular metastases develop at some stage in the history of malignant parotid tumours in a considerable proportion of cases (50 per cent., Ahlbom). About a quarter of them are in the parotid lymph gland, and are therefore unsuitable for surgical treatment. The remaining three-quarters are in the glands of the neck, and in this situation they are most efficiently treated by surgical excision, and, if they are enlarged but operable, a block dissection should be done (p. 1736).

It is difficult to say to what extent the prognosis is improved by removal of glands of the neck which show no direct evidence of involvement. In advanced cases local recurrence and distant blood-borne metastases are both commoner than invasion of the glands, and in view of this a prophylactic gland dissection can scarcely be justified. In early cases in which the prognosis, apart from glandular invasion, is good, it should be considered.

Malignant tumours of the submaxillary gland should be treated by excision whenever possible. The glands of the neck should be removed at the same time, and the operation is identical with that described on page 1736.

CHAPTER XXXV

HARE-LIP AND CLEFT PALATE

By W. E. M. WARDILL

THE subjects of hare-lip and cleft palate are so intimately connected that it is impossible to consider one without wandering into the province of the other. For purposes of description, however, three main types (as described by Ritchie),* may be selected, namely :—

A. Pre-alveolar clefts, in which the lip, or lip and nostril alone are split. (Fig. 744, A.)

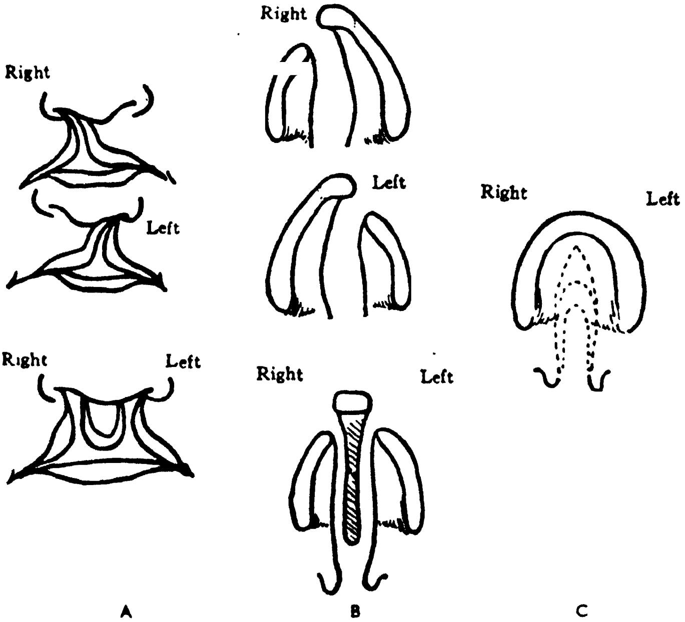

Fig. 744.—A, Pre-alveolar clefts, right, left and bilateral. B, Alveolar clefts, right, left and bilateral. C, Post-alveolar cleft.

B. Alveolar clefts where the split involves the lip, alveolus and palate. (Fig. 744, B.)

C. Post-alveolar clefts, in which the palate alone is cleft. (Fig. 744, C.)

In pre-alveolar and alveolar clefts the lesion may be unilateral or bilateral.

ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

In general it may be stated that clefts of the lip and palate are associated with changes in the architecture not only of the underlying bones, but of the whole skull.

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* *Arch. Surg.*, Apr. 1934, xxviii,, 617-58.

A. Pre-alveolar cleft.—This type affects the lip or lip and nostril alone. It varies in extent from a small notch in the red margin to a complete split which involves the floor of the nostril but does not extend through the alveolus. Despite the apparent truth of this, Broderick has recently shown that X-ray examination of the upper jaw in such cases frequently reveals a definite cleft of the bone, although the overlying soft tissues appear to be in the normal relationship. The importance of this observation lies in the fact that, even with the simpler types of cleft, underlying bone changes may cause persistent deformity after repair.

It has been my practice in dealing with these pre-alveolar clefts to defer operation in the simpler types until the age of about a year. In the more extensive types, where there is associated flattening of the nostril, it is better to carry out the operation, if possible, within the first three months of life. During the course of repair, the muscle of the lip is restored and its sphincter-like action has the effect of remodelling any abnormalities in the skull bones. Moreover, these bones can, at this time of life, have their architecture altered very simply by the natural activities of the lip muscles and other soft tissues.

The aim in the repair of the lip is, of course, to secure, as far as possible, a cosmetic result, and this object is more easily attained where function is made the first consideration. This being so, it can be said quite definitely that a result obtained at one operation can never be permanent because of the alteration which takes place in the whole of the face and jaws, and it is well to promise nothing more than this, leaving any secondary cosmetic adjustment which may be necessary to a second operation.

B. Alveolar cleft.—In this type, which passes through the alveolus to one or other side of the premaxilla, changes in the structure of the skull are more obvious. Where the cleft is unilateral, the vault of the skull is asymmetrical, the frontal and parietal eminences on the side of the cleft being displaced backwards in relationship to the opposite side. In addition, the upper jaws are splayed apart and the nasal septum, including the vomer, is displaced to the side away from the cleft. Very frequently, the maxilla on the side of the cleft lies posterior to that of the opposite side. The premaxilla is consequently rotated away from the cleft, so that restoration of the dental arch is difficult and sometimes impossible. Where the alveolar cleft is bilateral, both upper jaws are displaced posteriorly, and the premaxilla is mounted on a strong buttress of vomer. Frequently the premaxilla is also rotated to one or other side, or displaced upwards. Restoration of the dental arch, once again, is either extremely difficult or impossible.

In alveolar clefts, second only in importance to the repair and consequent utilization of the lip muscle is the formation of a floor to the nose, and naturally this cannot be effectively carried out unless the hard-palate defect is repaired at the same time. This also has the advantage of making subsequent repair of the palate much simpler and more certain ; in fact, if this treatment is surgically successful, little more than a soft-palate cleft remains for later treatment. It is to Victor Veau* that we owe the credit for this procedure, and his operation has certainly proved invaluable. The principle of Veau's method consists in raising the muco-periosteum of the hard palate on the cleft side and suturing it to a previously prepared flap from the muco-periosteum of the vomer.

It is important to realize in dealing with this type of cleft that early operation is indicated, in order that the moulding process supplied by the muscles and other soft tissues should have its maximum effect. It is also important to realize that the pull of living tissues is far more effective in reconstructing such bone deformities than either the excision of portions of the vomerine buttress or removal of the premaxilla. If bone is removed, flattening of the upper lip with ugly deformity is inevitable. Fig. 745A shows the type of deformity, which necessitates subsequent operation for the correction of an extremely unsightly lip. On the other hand, the premaxilla does not always come into a natural relationship with the jaws, even in spite of early operation, but in such circumstances there is nothing to prevent its correction at a later date by removal of the bone. The degree of moulding which can be effected in these cases is illustrated by Figs. 745B and C.

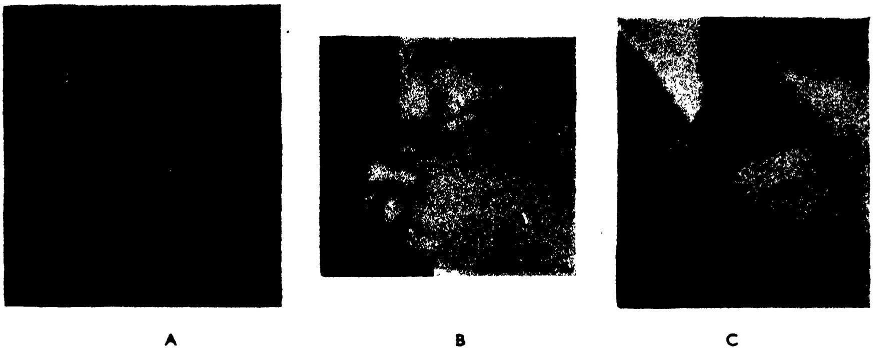

Fig. 745.

A, gross deformity of the lip following excision of the premaxilla or of part of the vomer. B, bilateral alveolar cleft before operation. C, same case as B eight months after repair of both sides of lip and floor of nose. No attempt made to replace premaxilla by removal of bone. Note natural lateral contour of the upper lip.

C. Post-alveolar cleft.—These clefts involve the velum to varying degrees and can extend along the hard palate as far as the alveolar margin. In most cases the dental arch is regular, suggesting that there are no changes in the shape of the skull. Such, however, is not the case, as is seen in Fig. 746, which demonstrates the flattening of the face which occurs with an uncorrected post-alveolar cleft involving the bone of the hard palate. The appearance is quite characteristic, and the face almost Mongolian. In such clefts the upper jaws are splayed apart, and measurements conducted by myself some years ago demonstrated this fact.* The importance of the splaying apart of the maxillæ lies in the fact that there is an associated increase in the lateral diameters of the naso-pharynx. I believe, but have never been able to prove by actual measurements, that there is also an increase in the antero-posterior diameter. This fact is of paramount importance, since the aim of treatment of cleft palate is to construct a palato-pharyngeal sphincter mechanism ; that is, a mechanism which, during speech, closes off the oral and nasal cavities so that air cannot escape down the nose and thus give rise to the characteristic cleft-palate speech.

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* "Division Palatine," Masson et Cie., Paris.

There is, in addition, in post-alveolar clefts, some paucity of soft tissues. The tensor palati muscles, which have never been fully put into use, are naturally shortened. Consequently, attempts to re-suture the palate in the mid-line bring inevitable tension on these muscles. The palate thus tends to become fixed and immobile from the bowstring-like action of these two tendons, which hook around the hamular processes. The tensor palati is essentially a muscle of deglutition, its principal function being to expel the bolus over the back of the tongue, very much in the same way as an orange pip can be squeezed between the fingers. It also acts in conjunction with the palato-pharyngeus and palato-glossus muscles in drawing the palate away from the posterior pharyngeal wall. Putting the tensor out of action seems to be associated with no functional disability.

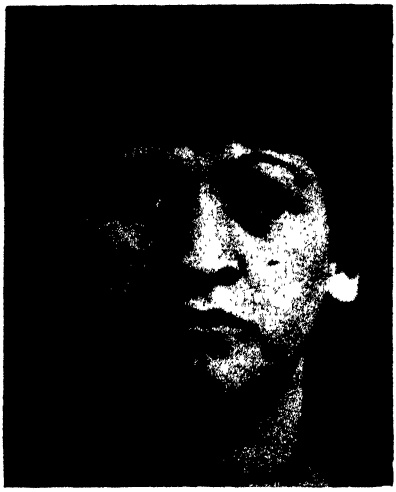

Fig. 746.—This patient has a wide unrepaired post-alveolar cleft. Note breadth and flattening of face.

The muscles which are responsible for closing the naso-pharynx and forming the sphincter mechanism are the levators, which raise the palate upwards and backwards towards the pharyngeal wall, and the superior constrictor muscle, which acts synchronously with the levators and produces a ridge on the posterior pharyngeal wall, thus completing the sphincter mechanism. This latter muscle acts not only in producing a ridge (ridge of Passavant), but also in narrowing the diameters of the naso-pharynx from side to side. Evidence of the competence of this sphincter is seen in the ability to inflate balloons and to snort, as in clearing the pharynx of naso-pharyngeal mucus. Neither of these functions is possible to the patient with an unrepaired cleft of the palate or in whom, as a result of operation, the palato-pharyngeal sphincter mechanism is not competent. The aim, then, in repair of the palate is to produce a competent palato-pharyngeal sphincter.

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* *Brit. Journ. Surg.*, 1928, xvi, 127.

Unfortunately, it is the experience of most surgeons to be presented with cases of cleft palate, principally of the post-alveolar type, in which no operation has been carried out or in which such an operation has been unsuccessful. There is no limit to the age at which surgical treatment can be undertaken, but it must be realized that, although a successful anatomical and physiological result may be obtained, there may be little or no improvement in speech. Such cases must inevitably be submitted to a course of training. The prognosis will depend on the ambition, intelligence and auditory acuity of the patient. A further factor of importance is the type of speech which has already been developed. If articulatory bad habits are established, these must be corrected, and success will depend on the patient's ability to do this. Where there are no articulatory bad habits, it is possible to promise, in most cases, excellent speech results, with little or no training.*

Age at operation.—A. Pre-alveolar clefts.—The simpler types of hare-lip can well be left until the child has a good hold upon life, or until the end of the first year. This is not always popular with the mother, but is, I think, safer for the child. Moreover, in the interval, growth has taken place, and it is easier to obtain a good cosmetic result. Where the split extends into the nostril, with consequent flattening and perhaps deviation of the septum, earlier operation is indicated to allow that natural moulding of the skull which inevitably follows.

B. Alveolar clefts.—It is important to treat the alveolar clefts as soon as possible after birth, as it is in this stage of life that the maximum effect is obtained from the pull of soft tissues. It has been my practice in these cases to operate, if the condition of the child permits, at the age of about three weeks. There is much to be said for those who advocate operation within a few days of birth, since at this time the child is able to withstand trauma in a remarkable way. The operation should consist of repair of the lip and nostril, together with the formation of a floor to the nose. This can only be carried out if, at the same time, the cleft in the hard palate is repaired. Where the cleft is bilateral, the repair should be in stages—that is to say, one side should be repaired, the muco-periosteum of the hard palate being attached to a rotated flap of vomerine mucosa. The opposite side is done a month or two later. Secondary correction of the lip is nearly always necessary, but early operation has the advantage of causing rapid remodelling of the skull and, as has already been stated, leaves little more than a cleft of the soft palate to be dealt with subsequently, say at the age of a year.

C. Post-alveolar clefts.—This type of cleft is important principally because of the speech mechanism. It is imperative, therefore, to repair these clefts before the child begins to speak. A suitable age is about twelve months. With practice, operation on such small children does not present any very serious difficulties. The same remarks apply to those alveolar clefts which have been submitted to repair of the lip and hard palate in early infancy.

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* *Brit. Journ. Surg.*, 1933–4, xxi, No. 82, 347.

Pre-operative preparation.—First of all the child must be in good health, and free from chest complications, colds and so forth. It should have gone through a period of gain in weight during the time immediately preceding operation. Children with hare-lips and cleft palates are notoriously difficult to feed. They are often unable to suck the breast or a bottle, and are consequently at a considerable disadvantage. Each meal is a lengthy process which requires the greatest patience on the part of the mother or nurse. It can to some extent be hastened by feeding with a fountain-pen filler or a bottle bearing a premature teat. The greatest of all virtues, however, is patience. In infants the question of tonsils and adenoids does not arise, but in older children it is wise to make sure that there are no gross septic foci about the mouth. Minor degrees of sepsis do not seem to have much influence. It is as well to have the child admitted to hospital 48 hours before operation. Fever and threatened infectious diseases can sometimes be noted in this period. The child's normal feeds are continued until four hours before operation. One hour before operation, the stomach is washed out. Half an hour before the administration of the anæsthetic a hypodermic injection of 1/1,200 grain atropin is given. This dose applies to any child below the age of three months.

Anæsthesia.—Anæsthesia is best carried out by an endotracheal tube. The anæsthetic consists of oxygen and ether, preferably without the use of any re-breathing bag. This method is described by Dr. Philip Ayre.*

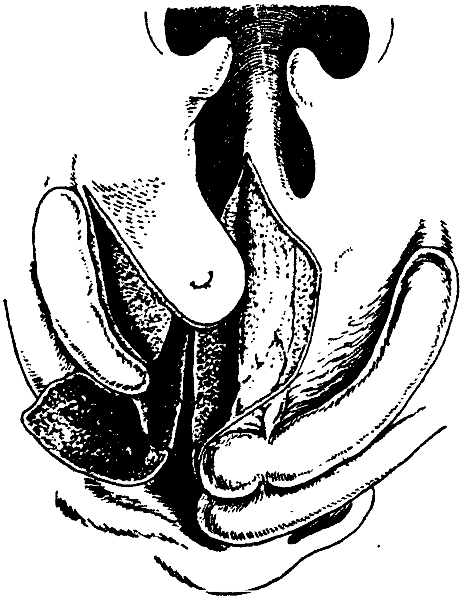

Fig. 747.—**Where the cleft is complete, the hard palate should be repaired as shown above at the same time as the lip operation.** (Reproduced by permission from "Division palatine" by Victor Veau.

For purposes of description, the repair of a complete unilateral or alveolar cleft will first be considered, since the underlying principles are applicable to any type of hare-lip.

OPERATION FOR COMPLETE UNILATERAL OR ALVEOLAR CLEFT

Repair of the hard palate and floor of the nose.—The operation is carried out under endotracheal anæsthesia. The pharynx is lightly packed with gauze to avoid aspiration of blood. The jaws are held open by a Lane's gag. Starting at the level of the maxillary tuberosity, an incision is made along the outer side of the hard palate, close to the alveolar margin, and passes forwards into the anterior edge of the cleft. The muco-periosteum

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* *Brit. Journ. Surg.*, 1937–8, xxv, No. 97, 131.

Fig. 748.—The shaded area shows the degree of subcutaneous separation necessary before attempting to unite the lip.

is then split along the free edge of the cleft as far back as the posterior edge of the bony hard palate. Using a small elevator, the whole of the hard palate is raised from its bed, but it is left attached to its blood supply from the posterior palatine artery. The flap is dissected up until the posterior edge of the bony palate is reached. An incision is then made along the full length of the nasal septum at the point of its attachment to the palatal process of the opposite side. An elevator is inserted into this incision, and a flap of mucosa is freely dissected up from the septum. This flap is then displaced laterally, and the previously separated flap of hard-palate tissue is sutured to it by two or three fine catgut sutures (3/0 chromicized). These are passed in such a way as to obtain the broadest possible contact between the raw surfaces. The mucous membrane of the lateral nasal wall is stripped up and sutured to the anterior end of the septal flap, which had previously been separated. In this way a determined attempt is made to form a floor to the nostril. The suture material is 3/0 chromicized catgut, and the sutures should be passed preferably as end-on mattress stitches. (Fig. 747.)

Repair of the nostril and the lip.—Most of those who are practising hare-lip surgery are indebted to Blair and Brown* for many excellent ideas, and these authors in turn pay tribute to the operation devised by Mirault. No attempt will, therefore, be made to describe this operation, but a compromise based upon it, and which has proved eminently workable, will be described.

Firstly, it must be recognized that, in order to produce a good lip and nostril, it is essential to free the suture line from all tension. This can only be done if the soft structures are thoroughly freed from the underlying bone. Kinking of the nostril on the cleft side is inevitable if the alar cartilage is not freed from the nasal process of the superior maxilla and also from its overlying skin. Repair of the nostril and lip are started by continuing forwards the incisions used in repair of the floor of the nose. These incisions are carried around the anterior end of the maxilla and premaxilla respectively, and are continued far along the gingivo-labial sulcus. Through the gap thus made, the soft tissues of the cheek and nostrils are raised from the underlying bone. Fig. 748 gives an idea of the extent to which this is carried out. Through the same incision the points of a pair of fine curved scissors are inserted and are passed between the alar cartilage and its overlying skin, the points being widely opened and effecting blunt dissection in the tissues between these structures (Fig. 749).

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* *Surg. Gynec. Obstet.*, 1930, li, 81.

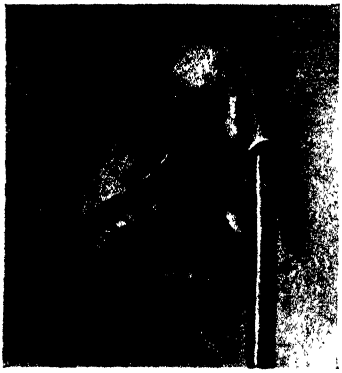

Fig. 749.—Sharp-pointed scissors are inserted between the alar cartilage and its over-lying skin.

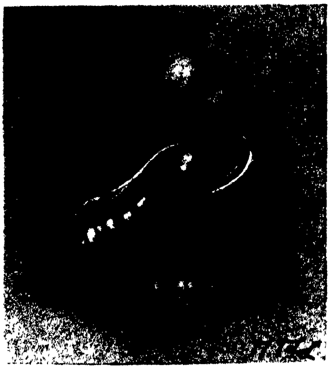

Fig. 750.—The incisions in the lip are outlined. It will be noted that the incision on the side of the cleft is curved, while that on the opposite side runs close to the red margin.

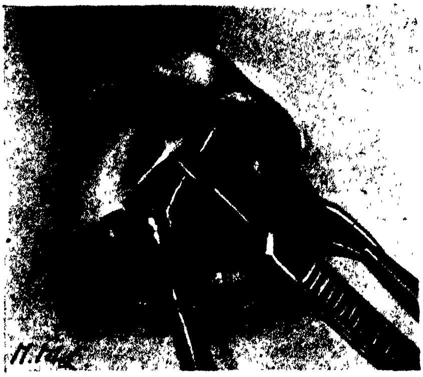

Fig. 751.—The flaps have been cut and the skin is being separated from the underlying muscle.

The next stage consists in the preparation of the lip-flaps. These must be cut in such a way that the two surfaces to be opposed shall be equal in length. This can be assured by plotting out the incision with a fine pen dipped in indigo-carmine or other dye, or by means of callipers. As will shortly be seen, the incision in the outer or cleft side of the lip is curved, and consequently callipers will not provide an accurate means of measurement. Much description can be saved by reference to Fig. 750, which is modified from Blair and Brown's paper. The incisions, commencing above, are carried through the whole thickness of the lip and terminate at the red margin. The incision on the side opposite to the cleft passes to the outer limit of the philtrum. The two flaps thus freed are left attached to be dealt with later. The skin of both prepared lip-edges is now undermined, either by a sharp knife or fine sharp scissors, in order to detach the underlying muscle and prevent infolding or depression of the suture-line ; by this means it is also possible to obtain more accurate and secure suture of the underlying muscle, which is, after all, the factor of greatest importance in the repair of the lip. (Fig. 751.) With this last step everything is ready for suturing. First of all, the alar cartilage is brought into its correct relationship with the columella, and a stitch of fine catgut is inserted but not tied at this point. Once this relationship has been accurately obtained by comparison with the opposite side, the floor of the nostril proximal to this point is sutured with 6/0 plain catgut, on this occasion the sutures being tied. The first suture to be inserted remains untied because it makes accurate apposition of the muscle possible. Altogether three sutures of 6/0 plain catgut are used to unite the muscle of the lip. Plain or unchromicized catgut is well tolerated by the tissues of the lip ; the use of buried chromicized catgut is often followed by troublesome sinuses which ruin the appearance of the suture-line. The sutures are passed from the inside in the form of end-on mattress stitches (Fig. 752). The first to be inserted picks up the muscle close to the alar cartilage and immediately beneath the suture first inserted to gain apposition. This is tied at once. This stitch is extremely important because it affords the principal support to the nostril and helps to maintain its shape. The second suture picks up the muscle in the middle of the lip and is once again tied on the inside. The third is applied near the level of the junction of the red margin and the skin, and is left untied till the flaps of red margin have been shaped.

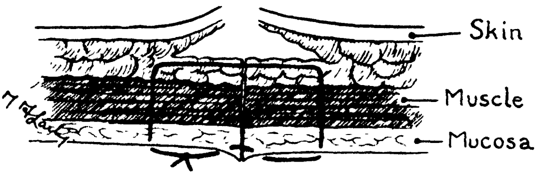

Fig. 752.—End-on mattress sutures embracing the muscle and mucous membrane of the lip.
Note that the sutures are tied from inside the mouth.

Fashioning the red margin can be done in one of two ways. Firstly, the previously-prepared flaps can be cut off by an incision which passes obliquely from the margin, leaving an excess of tissue to allow for subsequent contracture (Fig. 753, A), or the red-margin flaps may be fashioned according to the method described by Veau and by Blair and Brown, really a modification of the operation of Mirault. (Fig.

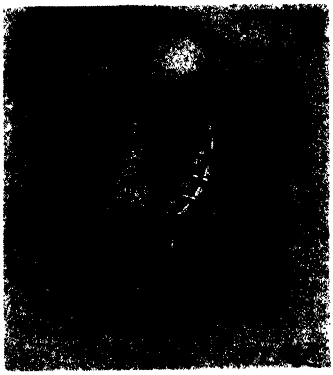

Fig. 753A.—One method of closure, showing some redundance at the vermilion border to allow for contraction.

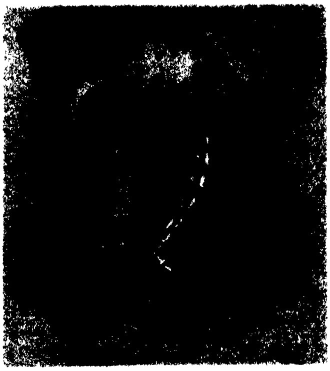

Fig. 753B.—The red margin flap on the side of the lip is larger than that on the other side ; it is pointed to fit into a previously prepared area of the opposite side.

753, B.) Whichever technique is chosen (the latter is undoubtedly the better) it is extremely important to get accurate apposition of the cleft at the point where the red margin joins the skin. Skin sutures, consisting of gossamer silkworm gut mounted on eyeless needles, are now inserted. They should be introduced close together and close to the skin edge and lightly tied.

Flattening of the nostril, in spite of free separation from bone and from skin, may still be troublesome. Some help can be obtained, however, by refixing the alar cartilage to its overlying skin by two or three fine mattress silkworm sutures passed through the full thickness of the nostril as in Fig. 754. Further help can be obtained by the insertion of a rubber tube, sufficiently large to fill the nostril. This can be retained for a week, being removed only for cleaning.

754.—Mattress sutures [illegible] sometimes prevent kinking.

After-treatment.—The operation is completed by applying a Logan's bow (Fig. 755, A), which consists of a malleable metal support with hooks which are used to affix pieces of adhesive plaster. After the bow is applied, its free ends are lightly squeezed together, so as to remove the tension from the suture-line. The suture-line should be smeared with vaseline and left exposed to the air, but the greatest care is taken to avoid the formation of crusts. Any crusts which form are gently mopped away, using fine pledgets of wool moistened with a little weak hydrogen-peroxide solution held by fine dissecting forceps. This may have to be done every few hours to secure the best possible scar. The suture-line is inspected after 48 hours and any sutures which appear to be tight, or any which appear to have tightened up with œdema, are cut, but not removed until 48 hours later. The sutures should be taken out on the fourth day without removing the Logan's bow, which is left in position for a full week. (Fig. 755.)

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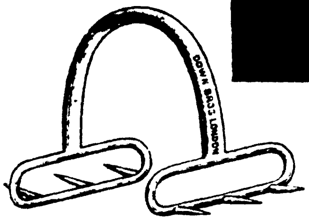

Fig. 755.—A, Logan's bow in position.

B, the bow.

Operation for Bilateral Alveolar Clefts

Bilateral alveolar clefts offer exactly the same problems in treatment as do the unilateral clefts. The problem is, however, complicated by two features of considerable importance. Firstly, the premaxilla shows a wide variation in anatomical form. It may be mounted firmly on the end of a very stout buttress of vomerine bone and, moreover, is often tilted upwards or even to one or other side, but in nearly every case it projects prominently forwards, and often beyond the tip of the nose. Excision of the premaxilla, or removal or division of the vomer, must be assiduously avoided, since this bone represents a firm base upon which to reconstruct the muscle of the lip, and consequently to remodel the whole skull. Proof of this can be seen in the fact that, within a few weeks of the attachment of one or both sides of the lip, the premaxilla has altered its relationship to the upper jaws, and consequently to the whole face. Fig. 745A shows the result of removal of the premaxilla, the gross retroposition of the lip producing a most unsightly deformity. Secondly, the prolabium, that is the isolated portion of the lip overlying the premaxilla, varies very greatly in size and in thickness, so that whereas in some cases it can be used in its entirety to fill in the gap in the lip, in other cases it is almost useless. If it be remembered, however, that the primary object in the closure of the lip is to obtain the pull of the muscles of the face, then the prolabium can be seen to offer a very important anchorage.

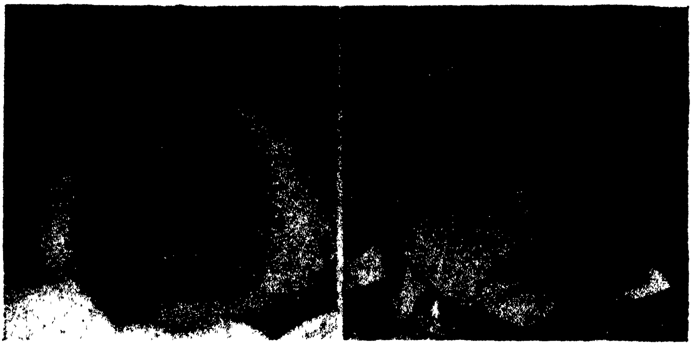

Fig. 756.—A, alveolar cleft before operation. B, same case at the age of two years. Some secondary correction of the lip margin is needed.

Bilateral complete clefts are best dealt with in stages and, since it is necessary to repair the hard palate and utilize vomerine mucosa on both sides, the prolongation of the operation and increased risk of sloughing due to wide separation of soft parts from bone are often more than little children can be expected to endure. Therefore the lip on the wider side of the cleft is repaired first, exactly in the same way as described for the unilateral cleft, with the difference, of course, that in cases where there is but little prolabium it is not possible to obtain a complete attachment for the muscle of the lip, and the surgeon is bound, therefore, to be content to make as good a job as possible

A B C

Fig. 757.—A, bilateral alveolar cleft. B, left side of the cleft repaired. C, same case after repair of both sides. Secondary correction both of the lip and floor of the nostril is required.

of the nostril and floor of the nose, leaving the complete reconstruction of the oral sphincter to a subsequent operation. (Figs. 756, 757.)

OPERATION FOR POST-ALVEOLAR AND PARTIALLY REPAIRED ALVEOLAR CLEFTS

The object of operating upon a post-alveolar cleft is to obtain a functional result, that is functional in so far as speech and deglutition are concerned. Normal speech depends upon the ability of the speaker to separate the oral and nasal cavities by means of the palato-pharyngeal sphincter mechanism. In the unrepaired cleft of the palate this is, of course, impossible. It is also impossible to attain this object by means of many of the operations at present practised, and the reason lies in the fact that in cleft palate the whole of the naso-pharyngeal diameters are markedly increased and, in addition, the palate is shortened and unable to reach the pharyngeal wall. The basic fault lies in the skull supporting these soft tissues. Before, therefore, normal speech can be restored, it is necessary to reconstruct a functional palato-pharyngeal valve. Moreover, this is all that surgery can do.

The names attached to operations for cleft palate are legion—which merely demonstrates the difficulties.

Brophy's operation was designed to close the cleft in the palate by the forcible approximation of the bony structures of the cleft with wire. In this country it has few or no adherents on account of the regularity with which deformity of the dental arch followed.

Lane's operation was performed within the first few days after birth and consisted in turning over flaps from one side of the palate to meet flaps from the other side. No satisfactory series operated on by this method has (to my knowledge) ever been demonstrated, but one fact is certain, namely, that the operation was frequently followed by gross maldevelopment of the jaws, as the resulting palate was quite rigid, and the functional results were bad.

The **Langenbeck-Fergusson operation,** on account of its simplicity, has had many advocates. It consists of simple suture of the cleft in the midline, lateral incisions being made close to the alveolar margin to allow thorough mobilization. (Figs. 758-762.) The primary fault in this operation is that no account is taken of the increased naso-pharyngeal diameters or of the paucity of the soft tissues. Moreover, as pointed out by Veau, the united flaps are left with a raw upper surface which is open to infection and, worse still, to subsequent scar contracture. The speech-results have never justified faith in the anatomical imperfections of the operation.

The **Veau operation** represented a new departure, in that he advocated the obliteration of all raw areas and the reconstruction of the palato-pharyngeal valve by suture of part of the component muscle,

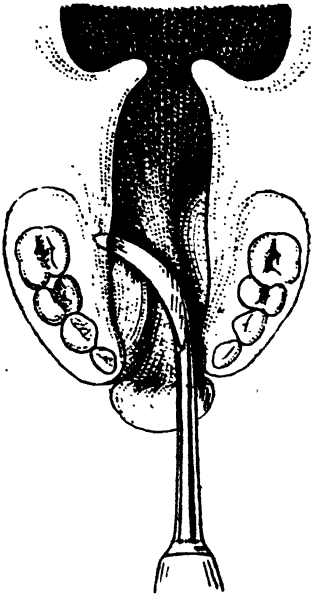

Fig. 758.—Langenbeck-Fergusson operation : Separation commenced from the cleft on the left side.

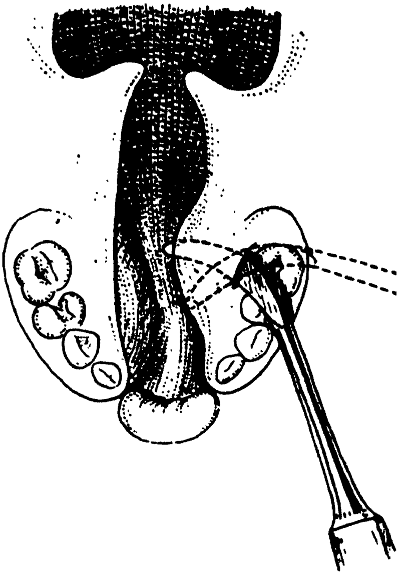

Fig. 759.—Separation from a puncture on the right side.

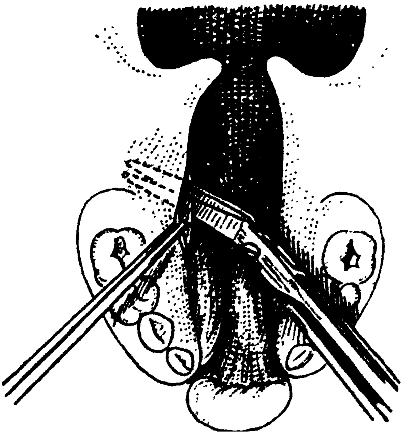

Fig. 760.—Detachment of the aponeurosis of the soft palate from back of bony palate, with the scissors used at a right angle.

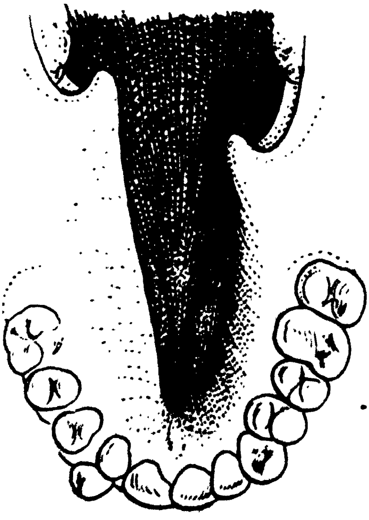

Fig. 761.—Narrowing of the cleft and elongation of the palate after thorough separation of the right side, in contrast to the left side which is not yet touched.

The first object was attained by using the mucous membrane on the nasal surface of the hard palate and the mucosa covering the vomer, and by designing the flaps in such a way that they lay snugly against the bone from which they had been separated. Reconstruction of the palato-pharyngeal sphincter he hoped to obtain by the insertion of a phosphor-bronze suture embracing the muscle of the soft palate on each side. Veau ignored the increased diameters of the naso-pharynx and the underlying altered architecture of the skull. His published results have marked a new era in cleft-palate surgery, and our present knowledge of the subject owes much to his work. Many of his methods are embodied in the operations described below.

Dorrance advocates an operation known as the " push-back," which is done in two stages and is apparently applicable only to those cases where the cleft involves the hard palate to a limited extent. Dorrance hoped by this means to push the palate back to the pharyngeal wall, and thus form an effective sphincter. As yet, he has not published his detailed results.

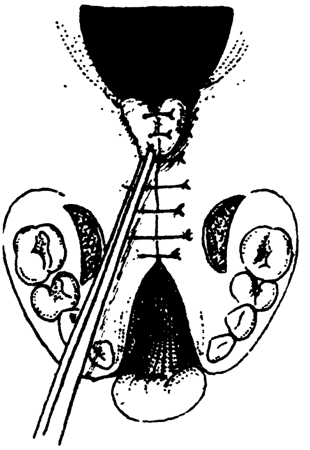

Fig. 762.—Small lateral incisions have been made. The sutures have all been tied, and the uvula is turned upside down to show its upper surface drawn together with two points of fine chromicized catgut.

The recommended operation.*. — The operation I have found most satisfactory does reconstruct functionally the palato-pharyngeal sphincter mechanism. It consists of two parts: firstly, pharyngoplasty; and secondly, repair of the palate. Pharyngoplasty was designed by myself, to reduce the increased diameters of the naso-pharynx by means of a transverse incision through the posterior pharyngeal wall, this being resutured in a vertical direction. The repair of the palate is the result of a gradual process of development in which much of the work of Veau is incorporated, and in which many of the ideas of the present day are brought into practical use.

The operation has the following advantages: Firstly, it enables a complete closure to be obtained at one sitting; secondly, with slight modifications, it is applicable to all types of cleft; thirdly, the V Y advancement obtained secures the greatest possible length of velum without any artificial juggling with the uvula or pillars of the fauces; and fourthly, it is quite definite that if the principles of the operation as described below are practised on infants below the speech age, i.e., before about two years, and a successful closure is obtained, the majority of these children will learn to speak naturally without any speech training, and will be indistinguishable from normal children.

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* *Brit. Journ. Surg.*, 1937–8, xxv, No. 97, 117.

Technique of the operation.—There are four principal stages: (1) preparation for the pharyngoplasty; (2) preparation of the palatal flaps and freeing from bony structures; (3) completion of the pharyngoplasty; and (4) suture of the flaps.

The head is thrown well back over a low pillow or over the end of the table. Illumination is of great importance, the best being given by a shadowless light, although a headlight, or even a single powerful bulb situated in the right position, will sometimes do. A transverse incision is made through the mucosa and the superficial fibres of the superior constrictor muscle of the pharynx, at the level where the ridge of Passavant normally forms during pharyngeal muscular movement. This level can be identified either by making the patient gag under light anæsthesia, or by noting the situation of the anterior arch of the atlas, which forms a cushion shortly below the level of the adenoid pad. The incision is best made by a No. 11 or 15 Bard-Parker blade, the hand being steadied by resting on the right cheek. Bleeding rarely gives any trouble, and can be arrested by the pressure of small gauze swabs wrung out of 1-150 carbolic acid solution. The lower edge of the incision is then picked up in long, fine, mouse-toothed dissecting forceps, and a special elevator (really a short aneurysm needle) is introduced between the superior constrictor muscle and its enclosing buccopharyngeal fascia. The point of the elevator is gradually worked downwards and from side to side until a considerable area is undermined, and until its point passes beyond the salpingopharyngeal folds. These are tight fibromuscular bands which lie on the lateral walls of the pharynx, passing in a vertical direction from the bullæ of the Eustachian tubes, and, in their lower parts, lying close behind the posterior pillars of the fauces (Fig. 763). During the whole of this

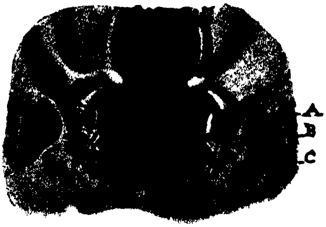

Fig. 763.—Transverse section of the pharynx in a case of cleft palate: A, Anterior pillar of the fauces; B, Posterior pillar; C, Salpingopharyngeal fold.

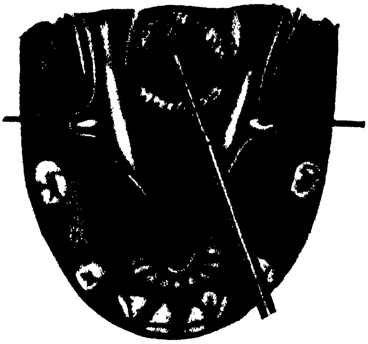

Fig. 764.—Pharyngoplasty. The elevator is introduced beneath the edge of the incision, and the mucosa and fibres of the superior constrictor are raised up. The shaded part indicates roughly the area of undermining. The dark vertical lines indicate nicks which are sometimes made to increase the raw area available for suture.

Figs. 763–782 are reproduced, by permission, from the *Brit. Journ. of Surg.*

process some resistance should be felt to the movement of the elevator; should there be no feeling of resistance, then it usually means that the buccopharyngeal fascia has been perforated and the retropharyngeal connective space has been opened. Having dissected the lower part of the incision, the upper part is now begun, and the undermining is continued as far as the base of the skull. At this point the elevator is removed and reinserted at the end of the transverse incision, the salpingopharyngeal fold is picked up, and the incision is continued into, but not through, the fold. This is repeated on the other side. Sometimes, when the denuded area so provided appears insufficient, a small vertical snip is made on the inner side of each salpingopharyngeal fold (Fig. 764) to increase the raw area available for suturing.

The process of suturing is now begun and, as the object of this part of the operation is to produce a ridge on the pharyngeal wall, and at the same time to narrow the nasopharynx from side to side, the incision is sutured transversely. The most important point in this connection is to take a big bite of tissue containing the salpingopharyngeal fold, the only really firm supporting structure in the posterior part of the nasopharynx. For this purpose No. 0 or 00 chromic catgut is used and is mounted on a ¾-in., half-curved needle, or on a large Reverdin needle. Suturing is commenced by picking up a large bite of tissue at the very end of the transverse incision, and including the right salpingopharyngeal fold. Where an ordinary curved needle is used it is held by a von Eiselberg or some such needle-holder. It is very important to have a needle-holder with the correct curve, and the von Eiselberg type has been found best for this purpose. The left-hand end of the incision is now picked up by the needle, and a good bite of the salpingopharyngeal fold is once again taken (Fig. 765). The catgut is left long and held by an artery forceps, and is not tied until a later stage of the operation. Altogether, four or five sutures are inserted,

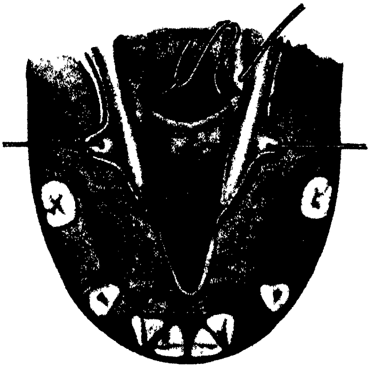

Fig. 765.—The needle is shown passing through the left salpingopharyngeal fold.

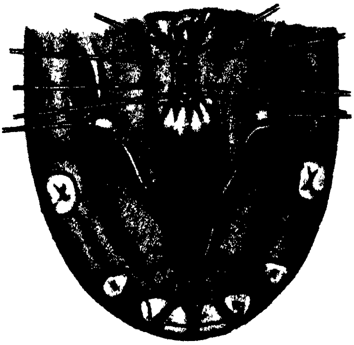

Fig. 766.—The effect of traction upon the sutures and how they tend to narrow the nasopharynx, the salpingopharyngeal folds being dragged together.

at least two of them gaining a good hold of the salpingopharyngeal folds, the others being used to unite the cut edges of the central parts of the incision. The operation when completed rarely looks neat, but when the sutures are tied it is seen that there is a marked reduction in the diameters of the nasopharynx (Fig. 766).

Preparation and freeing of the palatal flaps.—For the purposes of description it will be assumed that we are to deal with a cleft involving the soft palate and the hard palate as far forwards as the anterior palatine foramen.

The hamular process is first identified by feeling for it with the index finger (Fig. 767). An incision is then made on the outer side of this process and is carried along the hard palate, closely hugging the alveolar margin and extending nearly as far as the anterior end of the cleft. Then, inserting an elevator into the posterior end of the incision, the hamulus is identified and broken off (Fig. 768). In some cases it may be necessary to use the points of a pair of strong scissors. The importance of division of the hamulus cannot be over-estimated, since, by its destruction, the tendons of the tensores of the palate are released, and one of the greatest obstacles to easy suturing and free mobility is removed. A suitably shaped elevator is then passed into the lateral incision, and the mucoperiosteum of the hard palate is raised along the whole length of the incision. The elevator is then pushed inwards until its tip appears at the edge of the cleft. The mucous membrane over the tip is either lacerated thereby, or can be gently scraped through, using preferably a sharp-pointed dental scaler. This incision is carried round, dividing the junction between the oral and nasal mucosæ along the whole extent of the hard palate cleft. An oblique incision is now made on each side. Each incision commences at the posterior end of the hard palate and at the border of the cleft, and runs obliquely forwards and outwards (Fig. 769). The mucoperiosteum of the hard palate is completely severed and, of course, at this point

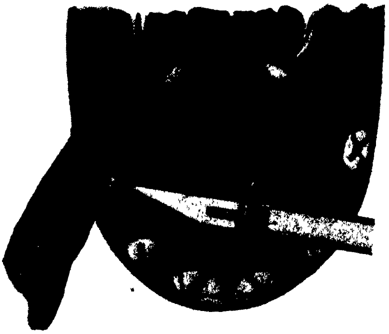

Fig. 767.—The index finger of the left hand identifies the hamular process. The incision commences to its outer side.

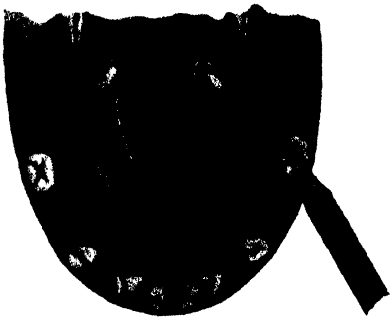

Fig. 768.—The elevator is introduced into the incision and the hamular process broken off.

there is often free bleeding. This procedure leaves four flaps, two anterior and two posterior.

The transversely oblique incision is made for a number of reasons. Firstly, Veau pointed out that when the hard palate is left intact, as in the Langenbeck operation (or Axhausen's modification), the mucoperiosteum is, as it were, left in mid-air with a raw upper surface which must inevitably granulate and, of course, give rise to dense scar tissue. Veau then devised his well-known method for the formation of flaps based upon the posterior palatine arteries, in which the upper raw surfaces were permitted to lie snugly against the bone from which they had been detached. Personally, I had never felt happy about the long Veau flaps, which rely for their blood-supply on a source which is liable to a good deal of trauma, or even to kinking over the hard rim of the foramen through which it passes to reach the flaps. This kinking must be exaggerated during the suturing, and it has been my experience that, in the widest types of cleft, one of the principal factors preventing the flaps meeting in the midline is the intact posterior palatine arteries. I am not convinced that pulling these vessels out of their bony canals can preserve a blood-supply adequate to allow any liberties. Consequently, by a gradual process, the oblique incision of Veau was brought farther and farther back, until now it is commonly made from the posterior edge of the bony palate, thus forming a very short posterior flap which allows deliberate division of the posterior palatine artery wherever necessary, and without any more fear of destroying blood-supply than in a similar flap anywhere else.

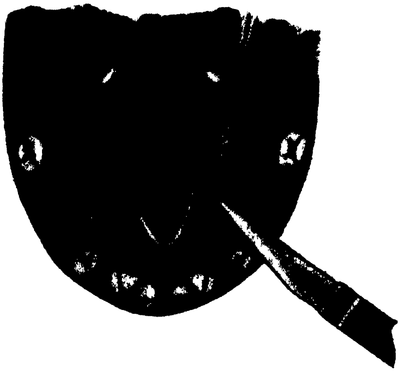

Fig. 769.—The mucoperiosteum of the hard palate is completely severed by an oblique incision.

Starting on the left side, the posterior flap is picked up either with a hook or with fine dissecting forceps, and is raised from its bed. Using an elevator once again, the flap is dissected up until the posterior free edge of the bone is reached. The elevator is then inserted behind the posterior edge until the soft palate is completely freed from the bone, and only remains attached by the mucous membrane on its nasal or upper surface. The elevator is then introduced on the upper surface of the hard palate, between the bone and its nasal mucosa, and this again is carefully raised along its whole length. After this procedure the principal structure which remains fixing the soft parts of the palate to its bony parts will be the posterior palatine artery and its sheath ; and, in many cases, unless the artery be divided, the palate cannot be sutured without tension. To deal with this the artery is gently pulled as far as possible out of its canal. A fine artery forceps is applied to the vessel close to the bone, and it is cut through and twisted (Fig. 770.) This leaves the whole of the bony attachment of the soft palate exposed, and the dissection is continued near the base of the hamular process and the maxillary tuberosity, and along the posterior border of the internal pterygoid plate, until the whole of the palate is quite loose and almost falls back into the naso-pharynx (Fig. 771.) It is advisable to take care, while carrying out this dissection, that it is not continued too far along the internal pterygoid plate, otherwise there is a risk of damage to the attachment of the Eustachian tube. If the separation is not felt to be free enough, a finger pushed into the lateral incision will often sever the few remaining strands which are anchoring the palate. Finger dissection is not by any means a new idea, and the first surgeon I saw practising it was Professor Grey Turner.

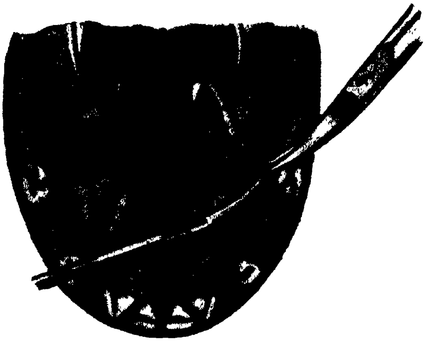

Fig. 770.—When necessary, the posterior palatine artery is seized, cut through, and then twisted.

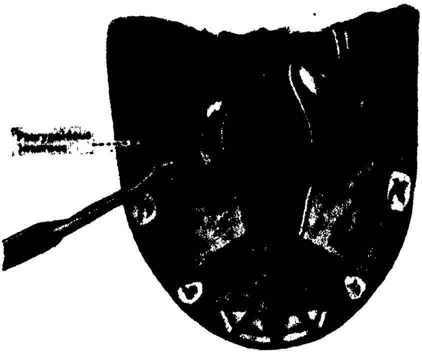

Fig. 771.—The greatest care is taken to get free separation of the soft palate from the bony surface of the hard palate. Note position of the pterygoideus internus muscle, and the fact that the nasal mucosa remains intact.

Now, when the wound is opened up for inspection, a large space will be found on the outer side into which the lateral incision opens. It is bounded on the inner side by the palate, and on the outer side by the tendon of the internal pterygoid muscle, which is often plainly visible. This space may be freely opened, since it does not communicate with the deep fascial spaces of the neck, and consequently any infection arising therein should not track into the mediastinum.

The operation, as described on the left side, is now carried out on the right; and, when both sides have been completed, the halves of the palate often lie in contact with the pharyngeal wall and with one another.

The next part of the operation consists of freshening the edges of the soft palate and the uvula, preparatory to suturing. This is done by excising a strip of mucous membrane by the usual method (Fig. 772) but often a little extra freedom can be gained by making a small snip with the scissors in the soft tissues, at the very front of the inner surface of the soft palate and close to the nasal surface (Fig. 773)..

Completion of the pharyngoplasty.—This consists in tying the pharyngoplasty sutures which were inserted in *Stage* 1. This process is delayed until this stage, because the raw edges of the incision now come together readily and without tension, and at the same time they drag with them the halves of the freed soft palate. Moreover, the soft palate is now held in a position of considerable posterior displacement.

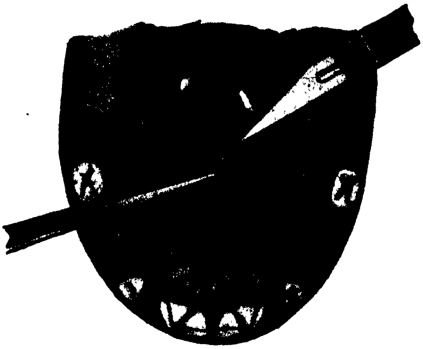

Fig. 772.—The edges of the soft palate cleft are freshened by excision of a strip of mucosa.

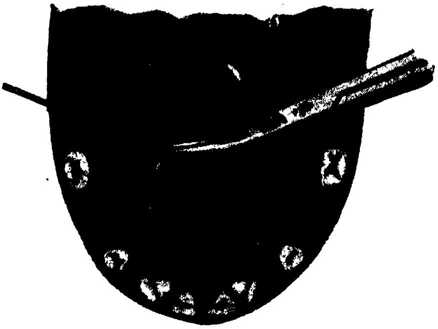

Fig. 773.—A little extra freedom and thickness of palatal tissue will sometimes be obtained by making a small cut with the points of the scissors as indicated.

Suture of the flaps.—The process of repair begins in front by suturing the mucous membrane from the nasal surfaces of the hard palate. (Fig. 774.) These are joined together in the mid-line, using fine catgut mounted on a needle. Several of the more anterior of these sutures are tied and left long, being held by small artery forceps. These are used

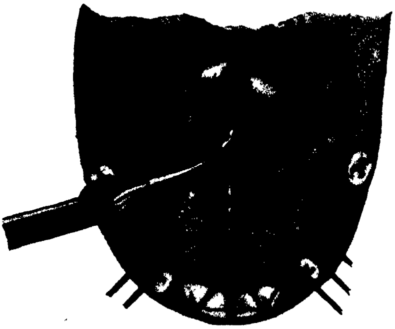

Fig. 774.—The nasal mucosa is sutured according to the method of Veau. Note that two of the sutures have been left long to anchor the flaps.

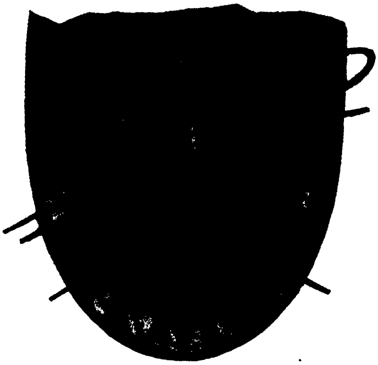

Fig. 775.—Insertion of the sutures into what was formerly the muco-periosteum of the hard palate.

later to anchor the flaps and prevent them from falling into the mouth. The suture of the nasal mucous membrane is carried along over the whole length of the soft palate and uvula. The oral surface of the soft palate is sutured with fine catgut, inserted in the fashion of the end-on mattress stitch. One or two of the more posterior ones take large bites of tissue and are tied lightly. There is no need for tight suturing, because everything is so loose that suturing can be carried out without tension.

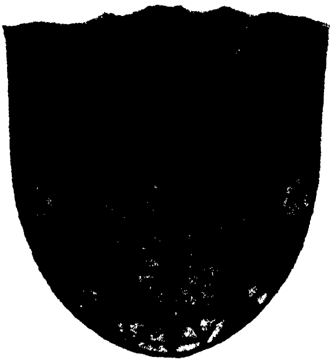

Fig. 776.—Completion of the suture line.

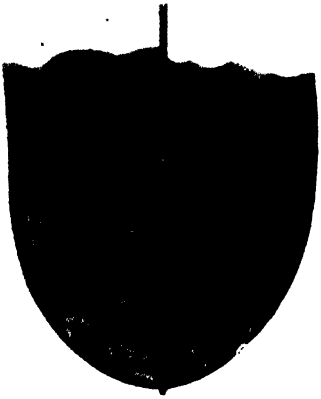

Fig. 777.—Illustrates diagrammatically how, by cutting flaps in the method described, a form of V Y advancement of the velum takes place. The letters indicate corresponding positions before and after operation.

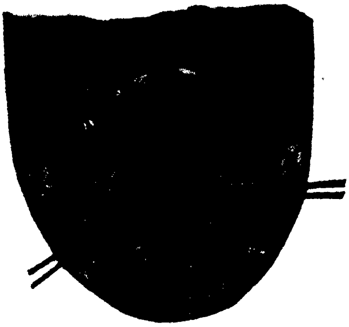

Fig. 778.—The mucosa from the nasal surface of the hard palate is united to the vomerine mucosa. The situation of the stay sutures is shown.

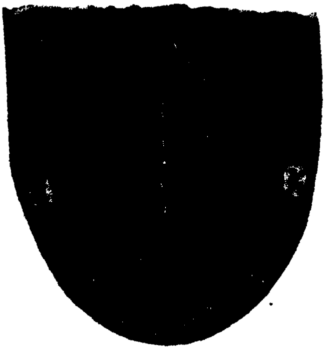

Fig. 779.—Repair completed. The dotted line shows the approximate situation of the united nasal mucosa.

As soon as the soft palate is completely repaired on nasal and ora surfaces, attention is directed to the two anterior flaps, which are raised from the underlying bone and united by two or three end-on mattress stitches. Next, the cut edges of the muco-periosteum of the hard palate (i.e. the edges of the posterior flaps), are united in a similar way (Fig. 775), and it is found that, in order to make the anterior and posterior sets of flaps meet at all, the suturing must be continued some distance along the posterior edge of the oblique incision (Fig. 776). Thus it is easily seen, as shown in Fig. 777, that considerable backward displacement of the soft palate has been effected, and in fact a form of V Y advancement carried out. In addition to this, there is a small gain in the fact that both anterior and posterior sets of flaps are subjected to internal rotation.

When the two sets of flaps are able to meet, the catgut sutures which were used to unite the nasal mucosa, and which were left long, are mounted on a needle and passed through both sets. (Fig. 778.) These act as stay sutures, and prevent the flaps from falling from their bed into the mouth. Two stay sutures only are required as a rule, and it is as well in passing them to arrange, if possible, that the suture line in the palate does not directly overlie that in the nasal mucosa ; as by this means there is less liability to the development of holes.

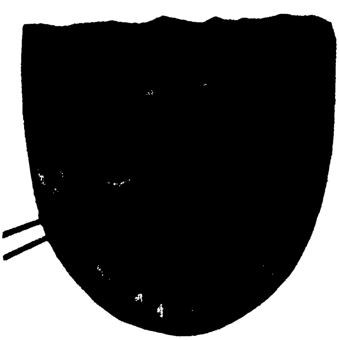

Fig. 780.—The vomer is attached to one side of the hard palate ; its mucosa can be stripped as shown and used to form a floor to the nose.

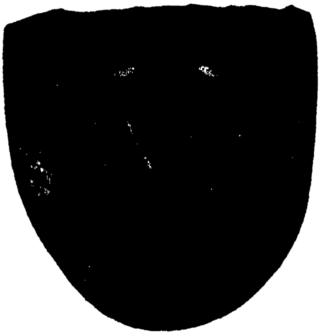

Fig. 781.—Line of incision for a soft palate cleft.

This completes the repair of the palate. The lateral spaces heal up quickly without giving trouble.

The method just described applies to that type of case where the vomer is not a prominent feature. Where the vomer is well developed, much use can be made of its mucosa, as shown in Figs. 778 and 779. If the vomer is attached to one or other half of the hard palate, as a unilateral cleft, its mucosa is used as in Fig. 780. In clefts involving the soft palate only, the same principles should be applied, as shown in Figs. 781 and 782.

After-treatment need not be elaborate ; in fact, the less local interference after operation the better. Food should consist principally of milk and slops, and each feed should be followed by a drink of sterile water. Custards and particularly jellies are gratefully accepted. Where catgut has been used throughout there is no need to remove sutures.

Children should be allowed out of bed as soon as the general condition permits. The elbows should be fixed in extension in light cardboard splints to prevent finger interference in the mouth.

Results.—After successful operation before the age of 2, by the method described, the majority of children will grow up as natural and normal speakers and require no speech training. Speech training is only necessary in failed cases and where operation has been unduly delayed.

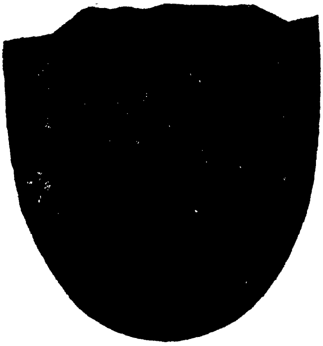

Fig. 782.—Repair completed. Note degree of advancement.

Holes in the suture-line should not be hastily interfered with, as they show a marked tendency to close spontaneously. Particularly does this apply to holes in the hard palate which can, if necessary and after the lapse of months, be closed by an obturator.

CHAPTER XXXVI

PLASTIC SURGERY

By Sir HAROLD GILLIES

Introductory.—Plastic surgery began in a war stage and then passed to a civil stage. Methods, proved efficient by trial in the years 1915–1921, were adapted and modified to civil conditions. Very substantial progress can be seen. First and foremost is the advance in the treatment of cleft palate. In the average case the surgeon can now expect to achieve the criterion of operation : perfect speech. Experimental work on the making of an external ear gives promise that in this hitherto tiresome defect a new, attractive auricle can be made by straightforward operation. Progress has been made in the technique of all skin grafts. There is, however, still a vast field for research in the problems of whole skin-grafting, blood-supply of flaps, metabolism of the skin, trophic troubles, incisions, sutures, and instruments. The effect of radiation and other physical agents on scar-formation, including cheloid, needs further investigation. The question of autologous and heterologous grafts is far from being settled. The scientific, artistic, and psychic value of plastic surgery is so obvious that I hope this article will still further help it to an honoured place in surgery.

It would be impossible here to give due acknowledgment to all the workers who, in the past, have contributed to this difficult branch of surgery, but I hope that the best points have been absorbed into the methods to be described.

Diagnosis.—In plastic cases diagnosis should be made with the greatest care and deliberation. The points to which particular attention must be paid fall under three headings :

1. Quantity of the lost tissues.
2. Character of the lost tissues, e.g., skin, mucosa, bone.
3. Shape of the lost tissues, in order that the shape and form of the portion to be transplanted may be accurately estimated.

Unless all these points are scrupulously attended to, mistakes in restoration will be very common.

It is also essential to make a decision on the *type of repair* best suited to the case in hand. This question is especially important when the plastic surgeon is called in to make good the loss occasioned by the removal of tissue by operations for malignant growths. He must decide whether some simple advancement operation will meet the requirements of the case, or whether the repair must be of a secondary plastic nature, to be carried out later. Operations involving only small areas of tissue about the lips or eyelids, more especially in old or infirm patients, lend themselves to the simple procedures ; while in younger, healthier patients, and where the loss of tissue is more extensive, the first operation should be carried out in such a way as to give the best possible ground on which to perform the secondary plastic restoration.

Record-taking.—*Plaster casts* may be of great help. On them the surgeon can and should plan out his operations beforehand. By working out to a nicety the loss of contour, he can provide an exact model of the missing mass. In addition, the casts provide him with the most perfect form of record with which to compare the final result, not only for his own or his patient's satisfaction, but also in case any legal dispute should ensue. From a practical point of view, however, they are difficult to make, somewhat irksome to the patient, and very bulky to preserve.

Photographs.—Next to the plaster-cast, photographs constitute the best form of record. Apart from their purely scientific value, as recording the progress of the case, they have a very definite psychical effect upon both surgeon and patient. Such photographs must not be retouched if they are to be of any real value, though it must be admitted that, even so, they fail to give precise records of all conditions.

Diagrams.—Stamp diagrams of the face and of the palate can be purchased, and on them the position of the small scars and many defects of the nose and lips can be adequately recorded. A tape measure should be on the consultant's desk, and the size of defects should be measured as far as possible. In insurance compensation cases, for instance, great stress is placed by the legal profession on the length of the scar.

X-rays.—Radiography is, of course, used extensively where the loss affects skeletal tissues, and in the demonstration of foreign bodies, including glass.

General principles.—The restoration of parts of the body destroyed or deformed as the result of congenital defect, trauma, surgical removal or disease should have for its main object restoration of function. Concomitantly with this it should be the aim of the surgeon to secure a good cosmetic result.

In all cases the principle of restoration in kind—bone for bone, skin for skin—is of the greatest importance. In this connection it is necessary to emphasize the utter futility of providing covering without lining whenever the loss extends into the nose or mouth or other cavity lined with mucous membrane.

Whenever such a wound is produced by surgical operation, as, for example, by the removal of a malignant growth of the lip, and when a simple advancement operation to meet the requirements of the case cannot be planned and executed at the time of the operation, it is best to suture skin to mucous membrane round the margin of the defect. This ensures the minimum of deformity and displacement, renders the skin round the defect available for turning in to form the lining required (thus doing away with the necessity for lined flaps), and in addition renders the operation a clean-healing one, unlikely to be followed by secondary hæmorrhage. Raw surfaces should be absent or reduced to the absolute minimum, in all plastic procedures.

Paraffin injection represents an easy road to perfect contour reproductions, and, unfortunately, is still recommended by some surgeons. The weight of evidence against it is so great as to make me hope that it will soon be considered unjustifiable. Apart from its well-known troublesome sequelæ, the impossibility of removing offending masses of fibrosed material constitutes a very real objection.

Planning an operation.—Every effort should be made to form a definite plan of repair, especially in the larger types of defect. It may be wise to give an example. It is by no means impossible to give a plan for another surgeon to carry out a specified repair, but minor, and quite often major, variations in the plan will always be found desirable, and, as the repair progresses, these variations of the original plan require imagination and elasticity of thought.

In a typical case of loss of the skin of one cheek, due to burns, the first step would be to make an accurate measurement of the whole of the area to be replaced. Due allowance should be included in this estimate for the retraction or replacement of normal tissues into their normal position when all the scar-tissue has been excised. It is quite easy to fail to realize the full extent of the loss. Great help can be obtained by comparing the damaged cheek with the normal one. A templet of the area is then cut in jaconet or stiff tinfoil, these materials being sterilizable at the time of the operation. When the donor site has been determined, the templet is placed on it and the skin marked by pricks with a needle dipped in Bonney's blue to delineate the flap. Several pricks may be made on the graft itself as identification points. It is then necessary to make a decision whether the repair should be a free graft of skin or a flap. There can be no doubt that a good flap to a whole cheek is far superior in cosmetic effect to any free graft. Therefore the decision will be " flap " unless some factor, such as age, time, or finance, indicates the shorter but inferior procedure.

The site of the donor area may then be chosen. In the male a flap may be raised from the anterior pectoral region. This is tubed in type and is carried on an acromial pedicle—an *acromio-pectoral flap*. In the female the lower opposite half of the abdominal wall is more satisfactory as a donor site ; the flap in this instance may be " direct " and not " tubed." The pattern is then laid on the donor site to ensure that there is sufficient skin available. It is well to allow for cutting the flap very slightly on the liberal side to allow final excision of its margins.

The time factor must be fully explained to the patient, and is the chief disadvantage of these repairs. The shortest time in which the flaps may be transported is shown in the following tables. Any attempt to hustle leads inevitably to eventual delay or disappointment. No allowance has been made on these tables for the final review and possible " trimming " of the flap. This must vary according to the circumstances of the individual patient. As a general rule, the flap should be reviewed three months after the last operation, but no harm (and often good) is done if they are allowed to settle for a year before any minor trimming of the joining scars and edges, or thinning, is undertaken. This operation can usually be performed under local anæsthesia and the period of hospitalization is short.

TABLE I.—TIME FACTOR. ACROMIO-PECTORAL FLAP TO CHEEK

	Procedure	*Anæsthesia*	*Interval*	*Total tim*
Operation 1	Pedicle and flap raised as a strap, outer part tubed, inner part re-sutured	Local or general	2 weeks	
Operation 1A	Outline of flap completely raised and re-sutured, a "delaying" operation	Local	1 week	3 weeks
Operation 2	Transfer to face	General	2 weeks	5 weeks
Operation 3	Pedicle cut and plastic completed. Donor area grafted	General	2 weeks	7 weeks

TABLE II.—TIME FACTOR. ABDOMINAL FLAP TO CHEEK

	Procedure	*Anæsthesia*	*Interval*	*Total tim*
Operation 1	Outer half of flap raised and attached to prepared area on back of opposite wrist, i.e. right abdomen and right wrist to left cheek. Raw area abdomen grafted	General or local	2 weeks	
Operation 2	Inner half of flap raised, but not cut across. Re-sutured	General or local	1 week	
Operation 2A	Delay operation. Incise three-quarters of inner border	Local	3 days	
Operation 3	Transfer of flap to upper part of face	General	2 weeks	
Operation 3A	Raise two-thirds of flap from wrist, attach and re-suture	General or local	3 days	
Operation 4	Complete division of flap from arm, bed into lower face. Suture wrist wound. Graft raw area on abdomen		2 weeks	8 weeks

Incisions.—All incisions should be made cleanly, and with a sharp knife. There appears to be no real advantage in any method of incision other than that in which the knife passes in a vertical direction through the skin.

Tissue trauma.—This must be reduced to the minimum, and to this end very fine-toothed forceps or, better still, fine tissue hooks should be used for holding the skin edges. Flaps of poor vitality are best held and manipulated in swabs moistened with warm saline.

Hæmostasis.—In this matter the surgeon is constantly in a dilemma between the length of time occupied in ligaturing every vessel, however small, and the amount of foreign material necessarily buried in the process, on the one hand, and the risk of formation of a hæmatoma—the worst enemy of the blood supply of a flap—on the other. The coagulating current is of considerable value.

Very fine catgut, or fine silk which allows even smaller knots, may be used where necessary, but direct crushing of vessels, or the use of mattress-sutures passing through the skin in order to obliterate dead spaces, is the routine.

Deep sutures.—Here again the introduction of more foreign material than is absolutely necessary must be strictly guarded against.

Deep catgut sutures may be required in order to obliterate dead spaces and to diminish the tension on skin-edges : the muscle and/or fat are united by sutures placed at right angles to the line of incision, their knots preferably being placed on the deep aspect. The actual skin, when tension is an important factor, can best be approximated by the mattress type of catgut suture placed parallel with the skin edges, and taking up the deep part of the dermis. Occasionally deep stitches should take their purchase from fixed points, if practicable beyond the area of the flap, as, for example, from malar bone to cheek, beneath a flap in this region. The edges of the flap are thus relieved of all strain on skin sutures. For these deep sutures very fine 11/0 catgut may be used on an eyeless needle. In neck wounds great care should be taken to mobilize and suture the platysma in this manner.

Skin-sutures.—For suturing the skin a fine cutting needle of a shape suiting the surgeon's preference should be used. The abdominal eyeless catgut needle has been modified suitably for skin-suture, and anyone who has once used an eyeless needle in the skin will never be content to go back to the older method. The strong demand for eyeless sutures that is springing up will bring the method within the reach of hospital and general routine.

Many varieties of stitch are used, the simple interrupted and the over-and-over continuous type most frequently. Fine silkworm-gut is suitable for sutures upon which little strain is expected. The continuous lock or blanket stitch gives nice eversion of skin-edges, and is particularly useful when the surgeon is working single-handed. Where there is much tendency to infolding of the skin-margins, the end-on mattress suture, either interrupted or continuous, is the most satisfactory. Mention should also be made of the triangular stitch for suturing three points with one stitch, the centre point being picked up subcuticularly.

Though the subcuticular stitch (usually of silkworm-gut, but occasionally of catgut) has the great advantage of absence of external stitchmarks, I have not found it especially suitable except in the straighter incisions where scar tissue is absent and there is no disparity in length between the edges to be apposed. It has, however, been much facilitated by the eyeless needle, and has now taken the place of many of the above methods. Greater care in placing the plane of

TABLE III.—FREE GRAFTS

TYPE	DONOR AREA	RECIPIENT AREA	METHOD
Skin grafts *Thin razor grafts* (Thiersch grafts)	These grafts are generally taken from the inner side of the arm where it is hairless	Thin razor grafts are mainly used in places where mucous membrane is normally present, e.g., in the mouth, called " buccal inlay " ; intranasal grafts ; for contracted sockets ; in the urethra	Instruments used : Blair or Thiersch knife, sterilized board and vaseline, the board being used to keep the skin at even stretch The graft is cut as thinly as possible Graft applied on " stent " mould with pressure
Thick razor grafts	The inner side of the arm or any aspect of the thigh or buttock. Immense pieces of graft can be cut with a Blair or Thiersch knife Large grafts and even grafts of desired thickness can be cut with a Padgett dermatome	The most common conditions in which these grafts are used are : granulating areas of the scalp and forehead ; cicatricial ectropion of the eyelids ; X-ray burns of the face and neck ; and loss of whole skin on the body or limbs. They are particularly applicable for replacement of skin on the hands, for webbed fingers, X-ray and other burns	Same as for thin except that the graft is cut considerably thicker Graft applied on " stent " mould with pressure ; or more commonly, wool soaked in paraffin and flavine may be used, tied in place by long ends of stitches *See p.* 1639
Dissected grafts (whole thickness grafts : Wolfe's)	The inner side of the arm, front of the chest, outer aspect of the thigh, the back of the ear and upper eyelid	Eyelids, and portions of the face in which a good cosmetic effect is specially worth attempting. When successful, they are more flexible and of better texture than razor grafts ; but the percentage of perfect successes is not so great as with the thick razor grafts. Indications for use : where there is cicatrical ectropion of one eyelid, and not of the opposite eyelid, enough skin may be occasionally found to repair the ectropic eyelid. Skin from the back of the ear can readily be obtained, and is useful for eyelids, loss of skin on the nose, and other small patches on the face*	The skin is excised in anatomical dissection, down to, but not including, the fat. The graft is cut to such a size and shape that when it is sewn into its bed it will be at the tension of normal skin—in other words, an exact fit. Pressure applied *See p.* 1640
Hair-bearing grafts These are also dissected grafts. Care must be taken to include all the hair follicles	The mastoid strip	Eyebrows and moustache	*See p.* 1669
Pinch grafts	The thigh	Clean granulating wounds where a cosmetic	

	the cheek	pres[illegible] n to form the lining of new eyelids. They also may be used in the urethra	a tiny razor. They are usually cut to the size of the part to be replaced and sewn in *Note :* Even the thinnest skin graft is likely to grow sufficient hairs to irritate an eye
Fat grafts	Fat is usually obtained from the abdominal wall, and frequently from the area of an existing scar. The more firm the type of fat, the less will its bulk be absorbed on grafting	The commonest application of fat method is for building up the contour of the cheeks or chin ; or for insertion beneath a previously implanted skin graft. They may also be used under depressed scars	A piece of fat is cut to the shape required and about 30 per cent. larger than finally required to fill the defect, to allow for shrinkage. It is then inserted underneath the depression
Cartilage grafts	(1) Costal cartilage. The free border of the seventh rib is usually taken, as it is the thickest and straightest possible (2) Septal and alar cartilages and the cartilage of the concha are of great use for minor deficiencies of the nose	Chiefly the bridge of the nose (*See* Bone grafts) *Example :* A curved piece of ear cartilage may be used to give support to a new ala nasi, or a new eyelid. Large pieces of ear cartilage may be utilized to give form to a new ear, but this type of graft usually has to be taken from a donor	*See p.* 1643
Bone grafts	Usually the ilium	This is the usual method of inserting new bone in the mandible, though block tibial grafts have also been used Osteoperiosteal grafts from the tibia have also been used with success in making a new mandible In restoration of the depressed nasal bridge this is now the recommended method	*See p.* 1644
Fascia lata grafts	Lateral aspect of the thigh	These may be used as contour padding in the same way as fat ; or in the form of bands or loops round the paralysed muscle in facial paralysis	*See p.* 1642

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[*] Cases will occur from time to time in which a completely detached portion of the face, and fingers or toes in particular, is brought up with the patient, having been retrieved and carefully preserved in the hope that the doctor might be able to regraft the portion. From a limited experience of this type of case, I very definitely recommend an attempt at this regrafting. I know one case in which the tip of the nose was cut off by a piece of plate glass and sewed back into place ten hours later. In three dog-bite cases portions retrieved, either from the dog or the ground, were regrafted, two successfully enough to obviate further treatment ; in the third a large portion of the forehead and eyebrow with frontalis muscle was sewn back, but was a complete failure. Advice : Keep the piece.

the stitch at equal distances from the skin surface has, by the excellence of the result, greatly increased its popularity. Either silkworm gut, a prepared silk such as Deknatel, or stainless wire may be threaded on an eyeless needle. The wire suture is becoming increasingly popular as it does not break, holds the skin edges nicely together, and is easily withdrawn. Perhaps the best results are obtained by using two subcuticular stitches, one for the deep and one for the superficial layers of skin.

External dressing methods to obtain an even pull towards the incision, so relieving skin tension, are strongly recommended. Ordinary Z. O. plaster, elastoplast, and, better in most situations, lastonet fixed with mastisol are in common use ; and in addition, enable some pressure to be applied over the wound itself.

Drainage.—Drainage should be provided whenever hæmostasis is incomplete.

Skin-grafting.—The methods of skin-grafting which find a place in plastic surgery are the *epidermic* graft (Thiersch), the *thick razor* graft used extensively at Sidcup in the 1914–1918 war and now named intermediate graft by some American surgeons, and the *whole thickness skin* graft used either as a flap (Wolfe-Krause) or as *pinch* graft (Reverdin). The latter is in reality a mixture of all three thicknesses of skin. The epidermic graft should be reserved for mucous lining, as in the mouth, nose, conjunctiva, urethra or vagina ; the thick razor graft is applicable to all clean raw areas, and is at its best on an area prepared surgically at the time, of a size which can be covered completely by one or two large grafts, and over which adequate pressure can be applied. Perfectly good results are obtained when this type of graft is placed on a fascial or muscular surface. The Padgett dermatome facilitates the taking of this graft.*

The whole thickness graft is reserved for special occasions and situations, because of the greater difficulty of its application. When successful, its advantages lie in the thickness and texture of the transplant. The pinch graft methods are best applied to large granulating surfaces which it is unwise to excise before grafting.

Numerous methods of fixation are employed, but all depend on the principle of pressure providing an intimate coaptation of the soil and the transplant. By far the greatest revolution in skin-grafting has arisen out of the pressure method of fixation. This is seen in its most startling form in skin-grafting a pocket in the mouth or nose. Esser deserves credit for his original idea of using a mould buried in the tissues, but far more do the Sidcup surgeons and dental surgeons who made it, by progressive modifications, into one of the most certain operations in surgery. Whenever possible, an accurate mould of the raw area should be made and the graft placed on the mould. If more than one graft is required, the pieces are so placed that their adjacent borders just overlap one another. On convex surfaces pressure bandaging suffices. Ferris Smith's researches in the direction of pressure-bag fixation are of great present and future value.

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* E. C. Padgett, Skin Grafting, Baltimore, 1942.

The moulding material most commonly used is Stent's—a piece of which is dropped into boiling water just before use. It is applied to the area when cooling off, and set thoroughly with cold sterile water. When ready, the mould may be fixed in position with strapping, mastisol fixation, or stitches across it. Another common method is to use wool soaked in paraffin and flavine, and to tie it over the graft by the long ends of the stitches.

In the mouth, various forms of dental splint are used ; splints fixed to the teeth are also used in grafting the interior of the nose ; while suture to adjoining healthy skin or simple fixation by adhesive strapping is employed where no other means is available.

The epidermic and thick razor grafts are cut with a razor or special Thiersch knife, and may be taken from any part of the body, though, as they must usually be hairless, the regions commonly sought are the inner aspect of the upper arm and the anterior aspect of the forearm and the thigh. The area chosen is cleaned with ether, and immediately before cutting the graft is again washed over with the same antiseptic. The area is shut off by sterile towels clipped round the limb ; the arm is held at right angles to the body by an assistant. An assistant applies a strip of wood on an arm at the upper extremity of the area while the operator manipulates another—the border of which is greased—in such a way as to lead the razor down the arm. Variations of pressure with the board will determine the tension and area of skin presented to the cutter. Some slight support from below with lateral stretching of the skin of the limb may also be required.

Various substances, such as sterile vaseline and saline, have been used to lubricate the knife and prevent rucking. Bold cross strokes of the razor, with even downward pressure, are required for the actual cutting, and the surgeon should aim at obtaining a graft of even thickness throughout.

Much experience is required to cut a large thin graft well.

Once the graft is cut, it is placed immediately upon the mould, already made in stent, of the area to be grafted, and is evenly spread over its surface with the raw part outside. The mould, with skin graft, is then replaced on the area to be grafted, and fixed in position by the most convenient means available.

A convenient method of manipulating skin grafts, especially if multiple grafts have to be fitted together, is as follows :—*Tulle gras*, a wide-meshed greasy material, of the size of the area to be covered, is placed on a flat surface on the instrument table. Several pieces may be overlapped and smoothed together. The grafts are now laid over this with their raw surfaces upwards, in such a way as to cover the entire area. Each graft is overlapped slightly over its neighbour so that there are no gaps at the joins. By lifting this piece of *tulle gras* carefully the whole can be carried in one piece to the wound. It can then be sutured to the margin with a few stitches, sufficient ends being left long. Pressure may now be applied by fine sponge, Sorbo sponge, wool soaked in paraffin and flavine, or eusol-soaked gauze, to make a flexible pad over the graft. The long ends of the stitches are tied over this pad, and provide very accurate pressure. Stent pressure may be used, with sponge pressure over that.

Wolfe's method.—A Wolfe graft is made from that portion of the skin which extends down to, but not into, the fatty layer. It is cut by a small scalpel in much the same way as skin is raised in the dissecting-room. The graft, which has been marked out by pinpricks in Bonney's blue, is cut of exactly the same size and shape as the area to be covered, for it is essential that it should be provided with conditions of tension as nearly as possible like those it possessed in its natural position. It is placed on the area prepared for its reception, and its margins are accurately sutured with fine stitches, close to the edge, preferably of the continuous type. Here it is especially necessary to bear in mind what has been said under the heading of tissue trauma (p. 1634), for every smallest damage is likely to show as a spot of localized gangrene in the finished result. A mould of the raw area is made in dental composition before the graft is sutured into place ; this, when fixed by the method illustrated in Fig. 783A, effectually prevents any accumulation of blood or serum between the graft and its bed. Here again is illustrated the principle of pressure-dressing.

Pressure is applied for a varying length of time. Ferris Smith aims at 30 mm. of mercury pressure for 12 days. Although successful Wolfe grants have frequently been seen with less scientifically applied pressure, it must be admitted that grafts which are viewed on, say the 5th or 7th day, have been occasionally observed to undergo, first, a filling-up or œdema, and subsequently, some form of trophic loss. So that if the pressure is still being successfully applied, and there is no other reason to disturb the dressing, my present inclination is to follow the ideal. Possibly some electro-therapeutic method may supplant this pressure method of preventing œdema.

The final colour of these grafts is not uniform. In some cases they take on a brown sunburnt appearance difficult to explain, while in others they never lose the somewhat glaring whiteness which robs them of much of their cosmetic result. The art of colour tattooing has a very definite place in plastic surgery. Wolfe grafts do best in positions such as the forehead, where it is possible to obtain good pressure-dressing. They fail to do so well when placed on yielding and mobile tissues where adequate pressure-dressing is not so readily applicable. However, by the latest methods of pressure-dressing even this difficulty has to a large extent been overcome.

Pressure methods.—Mention must be made of the *Coclst method* of providing pressure. He aims at stretching the base of the graft by suturing a frame of celluloid to healthy skin some distance from the margin of the wound. Round this frame tapes may be passed and tied over a mould of the raw area. Undoubtedly good results are obtained, but the principle is not different from that of leaving long ends of sutures to tie over sponge or stent pressure, and has the disadvantage of being more complicated, with a risk of distant stitch marks.

Perhaps the best of all pressure methods for a Wolfe graft (combining the advantages of all) is to make a frame that fits outside the wound area, out of a rope of black *gutta percha*. This, when laid on soft, will take up the contours of the wound surroundings, and when set will represent a firm ring following the contours. It should be about a third of an inch thick. After the graft has been sewn into position some long-ended sutures are tied to this frame and will produce centrifugal traction on the base of the area to be grafted. The ends are still left long after the knot has been made and can be used to tie down the sponge on to the mould and so produce an elastic and even pressure on the graft. This is possibly the first description of this composite technique. (Fig. 783A.) The recently-adopted method of inducing the skin graft to adhere to its bed by the production of an immediate fibrin clot has already greatly simplified the problem of fixation of the graft and the complicated pressure methods required to maintain close adherence.*

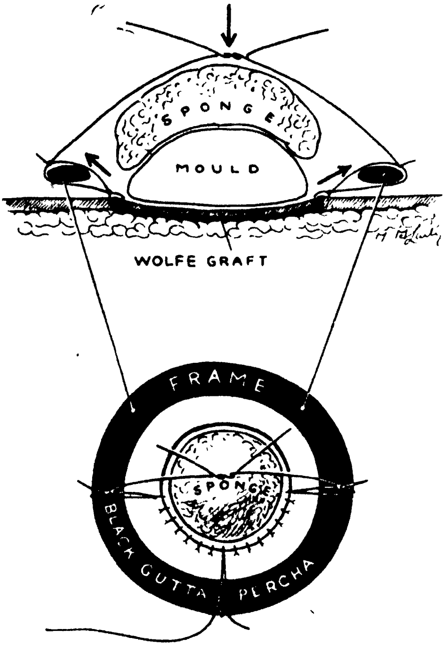

Fig. 783A.—Schematic diagram of method for obtaining tension and elastic pressure of Wolfe graft on its new bed.

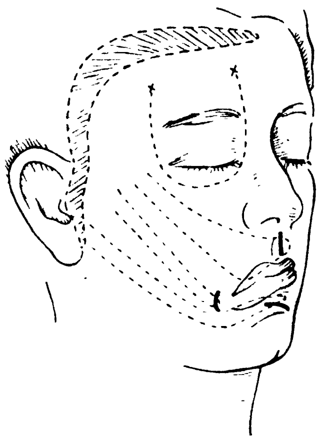

Fig. 783B.—Scheme of simple fascia lata bands used in facial paralysis.
(*A ter Blair.*)

Fat-grafting.—Little need be said on this subject. Pieces of fat are best obtained from the abdominal wall. Deep catgut anchoring-sutures should always be avoided if possible, and careful hæmostasis and accurate apposition of the skin-edges over the graft are of extreme importance. Asepsis should be very carefully attended to throughout, for the transplant is especially liable to infection. As fat varies in its fluid content, one-third allowance should be made for its contraction. Old fat-grafts of several years' standing show more fibrous tissue than at the time of transplant, but their survival cannot be disputed despite any writings to the contrary.

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* Sano, *Surg. Gynec. Obst.*, 1943, lxxvii, 510

Fascia lata graft.—The most common condition for which these fascia lata grafts is required is *facial paralysis*. A great deal of work in connection with the cure of this distressing condition has been done all over the world. At present the possible treatments appear to be as follows :—

Nerve grafting and nerve anastomosis.—Whenever this is possible it should take precedence over any attempt to alleviate the condition by the insertion of fascial bands. It has been pointed out, however, that when there is no galvanic response there is then a clear contra-indication to any nerve grafting, and cases of many years' standing usually fall into this category.

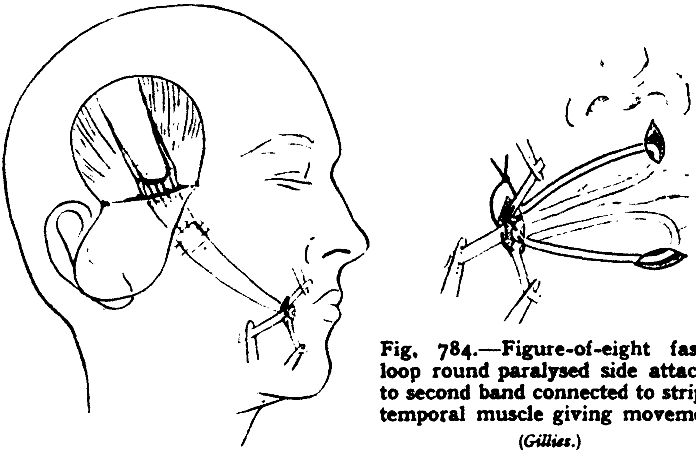

Fig. 784.—Figure-of-eight fascial loop round paralysed side attached to second band connected to strip of temporal muscle giving movement (*Gillies.*)

Fascia lata supports.—Where nerve grafting is contra-indicated, these fascial supports have a very definite value. Before their insertion care should be taken to eliminate all septic foci from the patient's buccal, orbital and nasal cavities. If the paralysis was caused by mastoid disease, everything possible should be done to make the mastoid cavity aseptic. The fascial strips are obtained from the fascia lata of the thigh by one of the well-known methods, that recommended being by the use of a ring stripper and fascia cutter. Fascial strips are then placed in loops in such a way as to take a hold on the muscles of the sound side of the upper and lower lips and of the corner of the mouth. The loops are passed by means of the Blair fascia needle through tiny incisions. The fixation point is usually the pre-auricular fascia. A satisfactory support is obtained by this simple operation, and there is both objective and subjective improvement. (Figs. 783B, 784.)

Activation of the face by attachment of fascia lata to temporal-muscle flap.—Activation of the facial muscles is now considered possible by attaching a flap of the temporal muscle to the band and loop in such a way that when the temporal muscle is contracted voluntarily movement of the face occurs, simulating facial expression.

Activation of the paralysed eyelid.—In 1917 I described a method of using temporal muscle and fascia to take the place of lost malar and lower eyelid muscles. Its bulk provided contour and its movement some expression. Since then many improvements have been made. The use of the temporal muscle and its fascia is a satisfactory method of obtaining muscular movement for the paralysed eyelid. A flap of muscle is cut rather far forward, and a considerable amount of temporal fascia is taken with it. By splitting this fascia it may be made sufficiently long so that, while still attached to its original muscle, a strip can be passed to the upper and lower lids to meet at the inner canthus. This little flap squeezes the two eyelids together. The muscle action is, as a rule, not very strong, but quite sufficient to give a definite support to the lower eyelid.

Cartilage-grafts.—After the usual preparation of the skin, an incision 4–6 in. in length is made perpendicularly over the central point of the ascending portion of the 7th costal cartilage, preferably on the right side of the body. A transverse incision gives a worse approach but a better scar. This is carried down through skin, subcutaneous fat, the rectus sheath and muscle, and the glistening surface of the underlying cartilage is exposed. By suitable retraction of the muscle on either side of the incision, good exposure may be obtained, and by working with the rugine around the lower border and deep surface of the cartilage, the portion to be removed is easily isolated from its muscular attachments. Considerable variety in the shape and size of the cartilages in this region is met, but, as a rule, the lowest cartilage seen represents the anterior slender extremity of the 8th, while the first complete cartilage crossing the wound is the more bulky 7th. The former is usually insufficient for the larger restorations, but is commonly taken and stored as a spare fragment. In cutting through either cartilage the rugine is introduced on its deep aspect to protect the underlying structure. Wrapped in a moist sterile towel, the pieces of cartilage are put on the small table set apart for the sculpturing which they must undergo before they reach their final destination. Bleeding vessels having been ligatured, the wound is closed in the usual way. Any useful fragments of cartilage left over at the end of the operation are buried subcutaneously, according to my method, in a pocket in the abdominal wall. The right iliac quadrant is the best region, for in this position the cartilage appears to give least trouble to the patient of either sex. Smaller restorations of nasal contour are sometimes affected by septal cartilage, while an alar support, or one for the stiffening of an eyelid, can conveniently be taken from the concha of the auricle.

Bone-grafts.—The ease with which cartilage can be obtained and cut to any required shape and size makes it popular in every branch of plastic surgery where restoration of contour is the main and only object of operation. However, much experience shows that it is very liable either to a change of position after implantation or to a change of shape. The degenerative process produced in the graft occurs unevenly, and too frequently with an ugly result. To avoid this the shaped iliac bone-graft has become the common graft for depressed nasal bridge. It is easily obtained and shaped, gets firm bony union with the bony bed to which it is attached, remains straight, and if, as rarely, it becomes mildly infected, it will resist destruction. In constructive rhinoplasty, however, where the whole nose has to be re-built, cartilage in the form of thin strips for the alar support and thick strips for the bridge support is still recommended (*see* p. 1656). For restoring lost portions of the mandible, iliac-bone grafting is an established procedure and is here briefly described.

Before operation the fragments of the jaw are fixed, by metal cap-splints and suitable bars fixed to the teeth, in a position as nearly as possible approaching that of normal occlusion. The gap is thus well defined when the ends of the fragments have been exposed and freshened. It must be emphasized, however, that the posterior fragment (especially if edentulous) has usually been pulled forwards and inwards, and should be freed so that the inter-position of the bone-graft will push it backwards and outwards into normal position. A submandibular incision is made, if possible in the line of, and at the same time excising, a previous scar. After careful protection of the skin-edges by towels, the wound is gradually deepened by excision of the dense scar tissue usually present between the fragments. Deep tissue flaps are preserved as far as possible, to provide covering for the graft. The ends of the fragments having been cleared and defined by the careful use of knife and rugine, freshening is carried out by means of bone-nibbling forceps or other suitable means, until healthy bleeding bone is reached. Near the angle of the jaw, where the bone is thin, the outer surface must be extensively freshened if union is to follow. When this freshening process is complete, and the ends of the fragments have been drilled to take sutures of stainless steel wire, the gap is ready to receive the graft, and all that remains is to plan and cut the latter and fix it in position by the ordinary rules of carpentry. A rough model or templet is made, in tinfoil or thin sheet-lead, the length and shape of the bone required.

The hip region is now prepared. With the patient turned well over to the side opposite to that from which the graft is to be taken, a curved incision, convex downwards, so as not to lie directly over the crest, is made down to the fascia covering the gluteus maximus, and the upper skin-flap is reflected. The outer edge of the crest being used as a guide, the gluteal fascia is divided and the upper fibres of the muscle are separated from the bone in such a way as to expose the outer surface of the ilium to a depth of about 1 in. over the extent required.

The templet is placed in position and outlined on the surface of the bone by chisel and mallet. These cuts are deepened until they extend through half the thickness of the ilium, when a wide thin chisel or osteotome, driven downwards from the upper surface of the crest, completes the separation of the graft. With Lane's bone-holding forceps the graft is transferred to a small table set apart for final trimming and drilling. The hip wound is closed by deep and superficial sutures ; drainage is always advisable.

The portion of bone removed consists of the outer cortical layer and half the thickness of the medulla of the ilium. Its texture is very similar to that of the normal mandible, and the half-thickness graft is about the same bulk as most parts of the mandible for which grafting is required. There is no necessity for taking the whole thickness of the bone, a procedure causing much greater interference with muscular attachment. The graft is so cut that its anterior extremity may be fixed to the posterior fragment of the jaw, and its posterior end to the anterior fragment, while the crest portion lies downwards and the cortical surface outwards. The ends of the graft are fashioned so as to fit the areas freshened for their reception as accurately as possible, and it is upon this part of the operation that much personal ingenuity has been lavished. Drill-holes are made to correspond to those of the freshened extremities, and the graft is transferred to its bed and wired in position by mattress sutures.

The deep tissue-flaps are drawn together by catgut sutures so as to make a good covering for the graft, and the wound is closed in the usual way, drainage being seldom necessary.

The time for which it is necessary to retain the splints varies considerably. In most cases they have been kept in position for from six weeks to two months. Though authorities on the subject have lately advocated very early removal, I am not convinced that this procedure, though it tends to early restoration of function, ensures the best occlusal results, unless some other means of preventing recurrence of the original deviation of the fragments can be planned. Union of the graft is usually well advanced at the end of the second month, and the new portion of jaw continues to get stronger as it takes on active movements.* Recently, excellent results have followed the use of multiple chips of the medullary portion of the ilium.

TABLE IV.—SKIN FLAPS

1. **Local flaps** taken from the neighbourhood of the defect when the donor area may be cosmetically repaired by direct suture :

Donor site	*Recipient area*	*Types*	*Closure of secondary defect*	*Special technique*	*Cosmetic result*
Immediate neighbourhood	Eyelids Lips Cheeks Chin } Minor or moderate losses	Sliding Advancement Rotation Transposed	Linear	Deep catgut antitension sutures	Colour natural Depends on character of scar

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* Gillies and McIndoe, The Late Surgical Complications of Fracture of the Mandible, *Brit. Med. Journ.*, Dec. 9, 1933, ii, 1060.

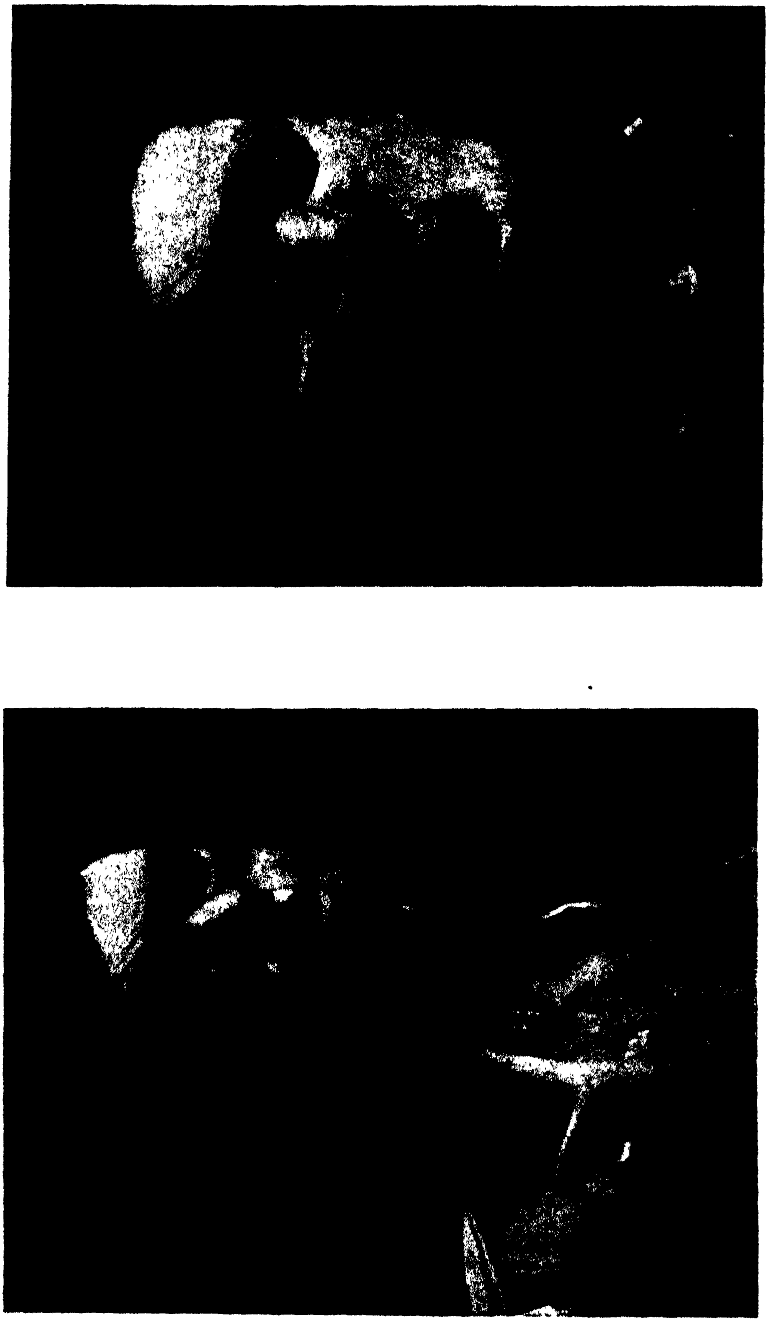


Fig. 785.—Severe airman's burn. Skin transferred by means of tubed-pedicle flap from chest and neck to nose and lip.

2. **Flaps from a distance.**—These have the advantage of introducing new tissue without any allowance having to be made for a secondary repair.

(*a*) *Without the use of an intermediate " host "*—a flap which by its own length can successfully bridge the intervening gap between the donor and recipient areas

Donor site	*Recipient area*	*Types*	*Closure of secondary defect*	*Special technique*	*Cosmetic result*
Forehead	Nose Cheek Chin (female)	Gillies " up and down " flap Double temporal pedicle Esser artery pedicle	Occasionally by advancement flap, generally by thick razor graft	*See* Fig. 796, p. 1660	Perfect colour Skin a little thick
Scalp centre	Male chin	The pedicle may be single, straight, curved, double, or with artery	Thick razor graft	Careful measurement of flap	Good, but stiff thick flap
Scalp anterior	Male upper lip Eyebrow		Direct suture		Good, but too bushy
Scalp posterior	Anterior defects of scalp	The flap may be sliding, transposed or rotated	Thick razor graft	Careful measurement of flap	Natural result
Neck	Lower face (male)	Direct or tubed	Linear		Good colour but different from face
Acromiopectoral	Nose Lower face } Especially male Neck	Direct, delayed or tubed	Linear or thick razor graft		Fair to poor colour, skin coarse Fair to poor colour, skin coarse
Double acromiopectoral	Whole face	Part tubed, part delayed	Thick razor graft		Satisfactory
Flank	Arm	Direct	Linear or graft	No need for delay as a rule	Excellent colour Full rounded effect
Abdomen	Forearm and hand	Direct	Linear or graft	Design by Gillies method	Rather thick for hand
Thigh	Opposite thigh Opposite leg Opposite foot	Direct or delayed	Thick razor graft	Design by Gillies method	Similar type of skin Big secondary defect
Leg	Opposite leg Opposite foot	Direct or delayed	Thick razor graft	Design by Gillies method	Sometimes unsightly secondary defect on calf

(*b*) *With an intermediate " host "*—a flap taken from a donor area so remote that it requires primary attachment to an intermediate host to bring it in contact with the recipient area. (Fig. 786.)

			defect	*host*	*technique*	*result*
Pectoral	Nose	Gillies tubed pedicle	Linear	Wrist	As for acromiopectoral but *via* wrist gives easier application	Healthy strong skin, often coarse, sometimes yellow
Abdomen-bilateral oblique	Scalp Total face Any large surface	Gillies tubed pedicle	Linear or graft	Wrist to centre of flap	Typical method	Healthy strong skin, often coarse, some times yellow but seldom pink
Abdomen-unilateral oblique	(1) Face in general (2) Any superficial part of the body	Gillies tubed pedicle	Linear or graft	Wrist to one extremity of flap		

SKIN FLAPS

The Gillies tubed-pedicle flap. (Figs. 785–787).—The principle of this flap was evolved in October, 1917, when the plastic surgeon was confronted with the difficulties of restoration of considerable portions of the skin of the face in severe burns. No facial flaps were available so that skin had, of necessity, to be brought up from more or less distant regions. The difficulty of obtaining a sufficiently certain blood supply was overcome to a great extent by the method described.

As an example, let it be supposed that the transfer of a large area of skin from the chest to the face is indicated. It is necessary to provide a flap whose pedicle shall be situated somewhere in the region of the base of the neck. A strip of skin, usually about 2½ to 3 in. in breadth, is raised from the neck and upper part of the chest (Fig. 787, A), its upper and lower extremities being left attached. The two edges of this strip are accurately apposed by a continuous fine suture, while the margins of the raw surface remaining are freely undercut in order to allow them to be brought into apposition by suitable tension and other sutures (Fig. 787, B). This latter procedure is facilitated by raising the shoulder on the side from which the flap has been cut and inclining the head towards it. When the flap is broad and the secondary approximation at all difficult, it is better to leave the under raw area to granulate under a paraffin type dressing. The flexibility of the resultant epithelium is truly astonishing.

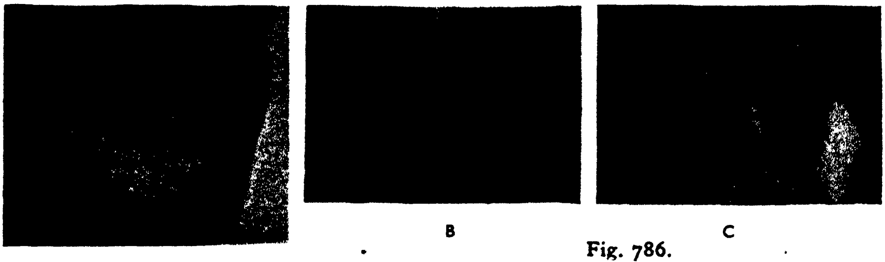


Fig. 786.
A, cheek loss due to lupus ; B, outer half of abdominal direct flap attached to back of wrist , C, transfer of flap to upper part of face.

The flap now forms a sausage-like tube of skin attached to the body at its two extremities. After about three weeks the lower end of the tubed flap may be separated from the chest and, being opened out to the required amount, may be applied to, and sutured in position on, the area to which it is to be grafted. (Fig. 787, C.)

After a further period of three weeks the upper end of the pedicle may be likewise separated and spread over some other part of the face, depending now for its blood supply on the previously grafted lower end. Various other transfers may be made, after suitable intervals of waiting, until the tube is completely used. If, after the first transfer, no further skin is required, the pedicle portion is divided from the part grafted and replaced in its original position on the side of the neck.

By means of the tubed pedicle, skin may be brought by stages from almost any part of the body to a desired spot, and it is in this respect that its introduction may be considered the most important advance in plastic methods which has been made in recent years.

Direct pedicle flap method.—In transferring a direct full-thickness pedicle flap from one part of the patient to another it is necessary to pay particular attention to its accurate design in order to avoid danger to the blood supply. The direct flap method is advantageous in that the number of essential operations is reduced to two with an interval of two or three weeks, thus shortening the length of stay in hospital very considerably.

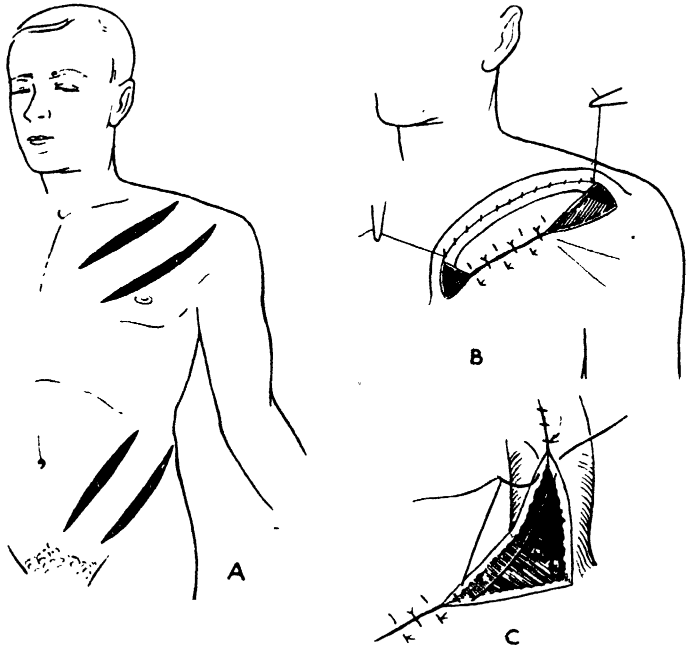


Fig. 787.—Tubed pedicle flap.

A, common donor sites for tubed pedicle flaps : the acromio-pectoral, especially in males, and the oblique inguinal. B, suture of a tubed pedicle flap. C, fourpoint suture. Triangular raw areas at each extremity.

The principle of the method of accurate design is to imagine the operation completed and to reverse the steps of the procedure of transferring the flap, using as a model an exact jaconet or linen pattern of the defect to be covered. It is thus possible to arrive with speed and accuracy at the correct topographical origin of the flap to be cut from the donor area. Suppose that there is a rectangular area over the posterior surface of the elbow-joint to be covered by a direct flap taken from the side of the abdomen. After the usual pre-operative preparation and sterilization of the pattern, the elbow is flexed and approximated to the side, bringing the defect as close as possible to the donor

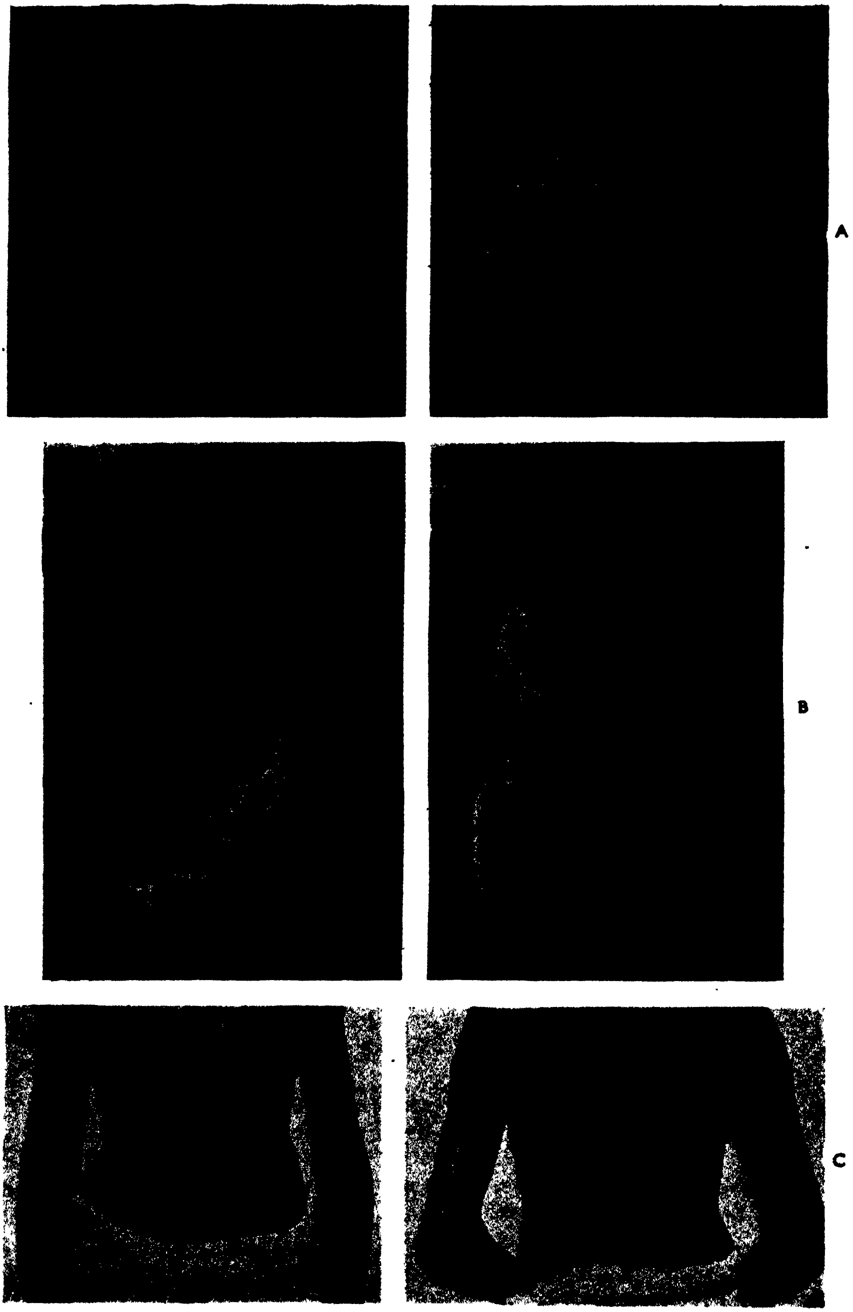
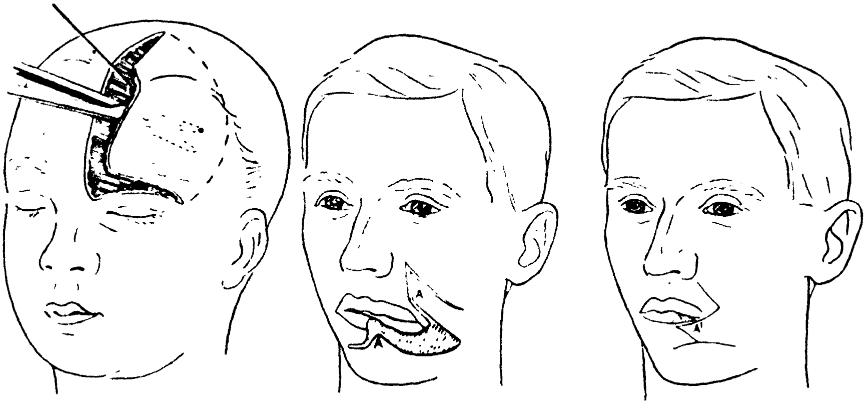


Fig. 788.

A, burn contracture of ante-cubital space. B and C, cure by direct lateral trunk flaps. Note in the back view B the temporary utilisation of the scar tissue as a means of fixation.

area. The pattern is now fitted accurately to the defect. The assistant holds the lateral edge carefully in position while the medial edge is turned over on to the abdominal skin and held by the surgeon in the position which it naturally takes, so as to leave the intervening portion comfortably slack. The lateral edge of the pattern is then released and the arm moved away from the side, while the surgeon smooths the remainder of the pattern over the abdomen. The skin outlined by the pattern is marked by scratching, and dissected up to form a flap, the attached side of the flap on the abdomen corresponding to the edge of the pattern first shifted to the body. It is necessary in some situations to allow enough extra skin at the base of the pedicle to ensure a sufficiently large area of the flap being sutured in position. After two to three weeks the attached end of the flap is divided and sutured into position on the arm. The line of division can be readily marked out by placing the pattern in position over it. (Fig. 788.)



A B C

Fig. 789.

A, undermining of flap for simple advancement. B, C, transposed flap. This example shows raising of corner of mouth.

The advantage of the method will be realized in direct transfers from limb to limb, such as calf or ankle to opposite leg or thigh. It will be found a great comfort to know that the flap will fit its new bed accurately without its having to be pulled into place by overstretching some portions or inserting stitches, which exert considerable tension. Gangrene and removal of stitches are thus largely avoided. Plaster fixation is essential for cross-limb flaps.

The same principle of reversing the operation is applicable in making the design for all tubed pedicle transfers, but it is not quite so essential owing to the great mobility and vitality of these flaps.*

Other forms of flap.—No useful purpose would be served by a detailed description of all possible skin-flaps. Essentially, all flaps are similar, and consist of two parts—the part chiefly concerned in the traffic of circulatory fluids, and the part available for plastic use. Broadly speaking, they may be grouped as (1) *advancement flaps* and (2) *transposed flaps*. (Figs. 789 and 790.)

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* Gillies, The Design of Direct Pedicle Flaps, *Brit. Med. Journ.*, Dec. 3, 1932,, ii, 1008.

Apart from those containing a definite artery, such as the superficial temporal (the base of which may be cut quite narrow), generally speaking the base should be at least as wide as any part of the flap, while the length which may be safely taken varies with both breadth and depth.

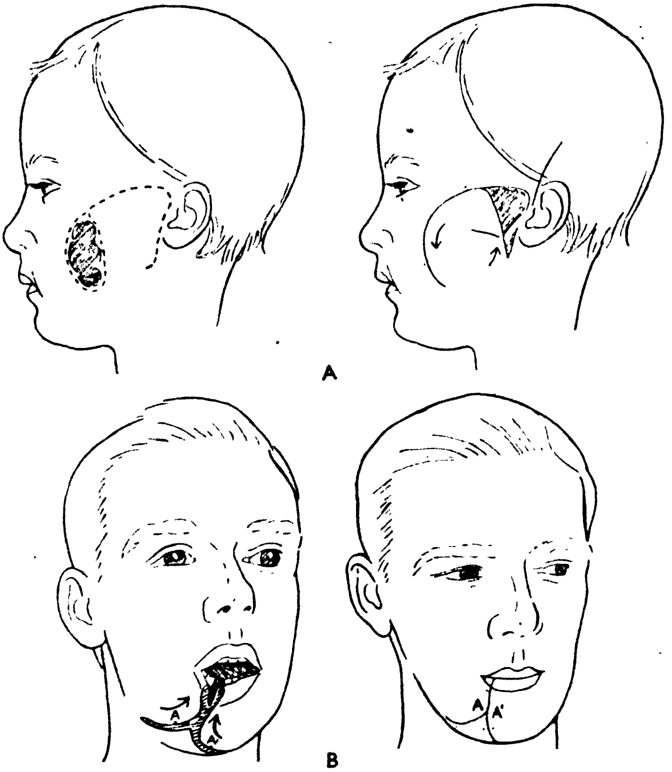

Fig. 790.

A, rotation flap. B, double advancing VY flap. Type to cure defect of lower lip.

LYMPHŒDEMA

The condition at the present time that should be treated surgically is one where the œdema is due to lymph blockage in the inguinal or iliac regions. This may arise idiopathically or may be the result of trauma of the lymphatics due to disease or operative interference. The condition of the arm is seen after certain types of mammary excision where the block is in the axilla.

The classical method of treatment is of the Kondoleon type in the leg. This consists of free excision of the subcutaneous tissue and deep fascia uniting the skin directly to the muscles. The principle behind this treatment is that the lymph of the limb is drained away through the muscles. It also has the advantage of removing hopelessly œdematous tissue. The results vary in different clinics ; but most observers agree that even in the good cases a mild recurrence is likely. This can be controlled by bandages. The Kondoleon operation should, therefore, be attempted in most cases. (*See* p. 539, Vol. I).

A second experimental method is to insert a piece of skin with its lymphatic vessels, the valves running in the right direction, across the line of the block. Thus, in conditions of the leg and thigh, a flap of skin from the inner aspect of the arm and the anterior aspect of the forearm is grafted from the inguinal to the mammary region so that the lymph runs up this bridge, and is drained to the neck *via* the axilla. It is too early to assess the value of this operation, but it is a favourable proposition in certain cases. That it has been a complete cure in a few patients is without doubt. In the arm conditions, a bridge of skin must go from below the axillary block to the root of the neck, and this bridge must contain the necessary lymph-valves. A method that has been used five times is to swing over the opposite breast to give drainage to the arm. Thus the lymph of an œdematous right arm may be drained through the left breast into the left axilla. All the cases in which this has been done show marked improvement. Unfortunately two of them were already suffering from neoplastic metastases at the time the operation was undertaken.

DEFORMITIES IN UPPER LIMB

Deformities to the Hand following Injuries to the Skin

Burns of the hand.—In this condition there is frequently scar-tissue contracture of the fingers. Whether only the palmar surface of the fingers or the whole of the palm be involved, the usual method of treatment is a free graft. As regards function there is little choice between a thick razor-cut graft and a Wolfe graft, but cosmetically the latter may be preferable. It is, however, more difficult to apply. When it is found necessary to graft the flexor surface of a finger it is usually desirable to carry the graft on to the side of the finger, so that any subsequent tendency of the joining scar to contract will not result in flexion deformity. There is a common conception that a free graft on the palm of the hand does not subsequently withstand manual labour. There appears to be no ground for this.

On the dorsum of the hand the same types of graft are desirable except in rare instances. When tendons are exposed it may be preferable to utilize an abdominal flap in order to provide a pad of subcutaneous tissue which will prevent adhesion between the tendon and the skin. These abdominal flaps are, however, as a rule too bulky to give good cosmetic result.

Recent trauma of the fingers.—In glove avulsion of the cutaneous coverings of the finger, the best treatment is the immediate application of a free skin graft. A more common condition is the oblique amputation of the tip of the finger, including, perhaps, the top of the nail together with the whole of the pulp. The phalanx is exposed and if these cases remain untreated their convalescence is slow and the end-result unsatisfactory. Cases have been recorded of the immediate resuture of the detached fragment plus the application of pressure. As a general rule the tip will survive. In the more extensive cases, or where the detached fragment is not available, the immediate application of a Wolfe graft after trimming back the exposed surface of the phalanx is desirable. In very severe cases it may be wise to attach a small abdominal flap, to restore the subcutaneous pad on the finger tip.*

X-ray burns.—These usually involve the dorsal aspect of the hand or fingers. Excellent results are obtained by free grafts, usually of the thicker type (p. 1639).

Loss of digits.—Probably the chief indication for operative interference is the presence of a functional thumb in the absence of any structure to which it may be satisfactorily apposed. In these cases it is wise to extend the stump of the hand in the region of the index finger, either by a tubed pedicle or an abdominal flap. This prolongation is subsequently stiffened by the insertion of a bone graft into the distal end of the first metacarpal. Occasionally this procedure may be carried out on the ulnar border of the hand as well as on the radial border. The cosmetic results are not necessarily good, but the functional result is satisfactory.

The other indication for operation is the presence of normal fingers and the absence of the thumb. If the metacarpal is intact, a short prominence may be added to give successful apposition to the finger tips. The bone graft should be set into the metacarpal at a slight angle of adduction ; prolongation of the metacarpal is thus obtained and is most satisfactory. Recently the operation of pollicization of the index finger has proved a practical and successful procedure.†

CONGENITAL DEFORMITIES OF THE SKIN OF THE HAND

Webbed fingers.—The majority of cases of syndactyly have not enough skin for the reconstruction of the contiguous surfaces of the two fingers. Perhaps the most satisfactory method of treating this condition is to reconstruct the web by two triangular flaps, with their bases proximally, one on the dorsum and one on the palm. These are sutured together and provide an effective check against any subsequent tendency to contracture. The fingers are separated as widely as possible. A skin-graft for the remaining raw area is inserted upon a stent mould and retained in position for from 10 to 14 days. This graft may be of the Wolfe whole-thickness variety or cut with a razor. It is usually unwise to divide more than one web at one operation, since the secret of success largely depends on wide separation of the affected fingers. In those cases of syndactyly where there are bone remnants of more than the requisite number of fingers, care must be taken to conserve only those bone elements which have associated tendons (*see also* Vol. I, p. 100).

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* See also, "Autograft of Amputated Digit," *Lancet*, 1940, i, 1002.

† Gillies and Cuthbert, "Plastic Surgery of Burns of the Hand," *Medical Annual*, 1943.

ACQUIRED DEFORMITIES OF THE HAND

Dupuytren's contraction.—The treatment of this condition depends on the degree of skin involvement.

1. In the absence of skin involvement a flap of skin and subcutaneous tissue is raised through an incision running transversely across the finger at the crease of the proximal interphalangeal joint. On reaching the ulnar border of the finger the incision turns and continues down to a point almost opposite the wrist. The flap of skin is raised sufficiently far to expose the whole of the involved palmar fascia. This is removed, the finger straightened, and the flap resutured into position. Even pressure by a sponge must be maintained for at least eight days, since the flap of skin is to all intents and purposes a Wolfe graft. The position of extension of the affected finger should be continued for a period of about six months by efficient nocturnal splintage.
2. Where there is involvement of the skin, the whole of the affected skin and palmar fascia is dissected away, and the fingers are fixed in full extension. A Wolfe graft is applied and kept in position by pressure. The post-operative treatment is similar. (*See also* p. 103, Vol. I).

DEFORMITIES OF THE FOREARM AND AXILLA FOLLOWING INJURIES TO THE SKIN

Forearm.—These deformities are chiefly the result of burns or extensive lacerations. Contracture in the region of the antecubital fossa is common. In the male this may be efficiently treated by a free graft. In women, however, where the cosmetic result is important, it is frequently desirable to replace, not only the skin in the region of the antecubital fossa, but also that of the whole of the forearm. This is best done by a flap from the flank, with joining lines on the radial and ulnar borders of the arm (*see* Direct flap, p. 1649). The same type of flap is sometimes desirable in cases of extensive laceration with involvement of the muscles, particularly when these are tending to contract as the result of fibrosis. The cosmetic results of these abdominal flaps to arm or forearm are so natural that it is difficult to distinguish which is grafted and which is non-grafted skin.

Axilla.—These also are usually the result of burns. When the axilla is occupied by a dense mass of fibrous tissue and the arm is closely bound to the side, the initial treatment consists in division of the scar, probably without removal of any tissue. The arm is adducted and the resultant raw area free-grafted. Secondary webs in either the anterior or posterior axillary-fold regions may frequently be dealt with by extensive Z-plastics. The incisions of this plastic usually require to be so wide that it is impossible to cure a contracture of both folds at the same sitting. Occasionally there is insufficient material in the axilla for a Z-plastic to be practicable. In these instances, a rotation flap from either the anterior or posterior surface of the body may be useful.

RHINOPLASTY

The case of the patient who, from disease or injury, has suffered loss of the whole nose will be taken as an example. It should be easy then to see how the method of dealing with such a case may be modified to suit individual less extensive cases. I do not propose to give a historical outline of rhinoplasty, nor to describe methods, necessarily based on isolated cases, which appear unsatisfactory on theoretical or on practical grounds.

In no branch of plastic surgery is the principle of *restoration in kind* of greater importance; skin, supporting structure, and epithelial lining must all be provided if the cosmetic result is to be at all permanent.

The operative treatment may be divided into the following stages:

1. Preliminary, establishment of air-way.
2. Subcutaneous implantation of cartilage to form scaffolding.
3. Rhinoplasty proper.
4. Return of the pedicle.
5. Skin-grafting of the forehead, general trimming, and final contour production.

Stage 1.—As the lining of the new nose is to be formed by turning in small flaps from those areas of the face bordering on the defect, it is essential that these latter should carry an efficient blood supply drawn from the mucosa upon which they abut. To this end, all scar tissue around the defect is carefully excised, with exact apposition by accurate suturing of mucous membrane to skin. It is at this stage, in cases of subtotal loss affecting the upper part of the nose, that the lower or terminal segment, which has usually become considerably displaced upwards by contraction during the process of healing, is thoroughly freed and allowed to take up its original and normal position.

Stage 2.—It is frequently possible to combine this stage with the former. Cartilage or bone having been taken, a thin flake about $\frac{1}{16}$ in. thick, $\frac{1}{8}$ in. wide, and in length equal to the extent of bridge it is required to replace, is inserted subcutaneously in the glabellar region. The insertion is best accomplished through a tiny incision in the midline between the eyebrows or higher up on the forehead, according to the length required. The cartilage is pushed downwards until it almost reaches the upper margin of the defect. (Fig. 791, A.)

Stage 3.—After a minimal interval of twenty-one days the rhinoplasty proper may be performed. A flap from the glabellar region is turned downwards, as in Fig. 791, B, to form the central portion of the lining of the nose. This flap carries on its deep surface (now outermost) and is supported by, the cartilage previously implanted. The alar portions of the lining are formed by lateral flaps turned inwards from positions on either side of the face above the upper lip, as shown in Fig. 791, B. In order to maintain the curve of the nostril, it is of distinct advantage to implant thin strips of cartilage in the regions from which these flaps are taken in Stage 2. Figs. 792–795 show alternative methods of carrying out this part of the operation.

The remainder of the lining is formed by small flaps turned in from the remaining margin of the defect. All these flaps should be worked out previously on the plaster cast of the patient, in order that the most may be made of the scanty tissues available. The adjoining margins of the flaps are united by catgut sutures of the Lembert type introduced in such a way as to invert all skin-edges slightly into the nose. Where possible, it is strongly recommended that the covering flap should be obtained from the forehead by the modern modification of what is usually known as the Indian method. Fig. 796 illustrates the incisions used for marking out such a flap. An exact model of the skin required should be made in tinfoil, and this should be placed on the forehead in such a position as to allow a pedicle sufficiently long to bring down the flap without any undue kinking at its point of attachment. Latterly, this pedicle has been made somewhat sickle-shaped, in order to carry it well clear of the eyebrow. Warning must be given against allowing a narrowed portion to occur at any point of flap or pedicle.

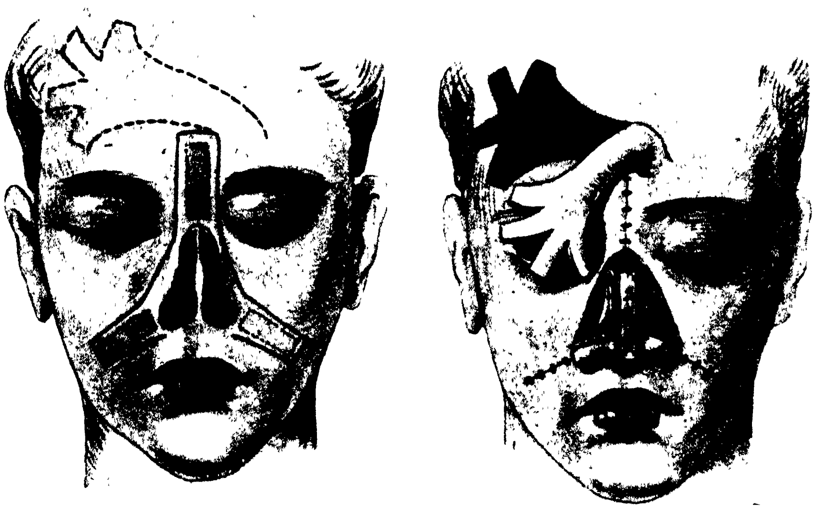

Fig. 791.—Rhinoplasty.

A, Airway established; supporting cartilages implanted. The outline of both lining and covering flaps has been indicated. B, Lining flaps turned in and sutured; forehead flap raised.

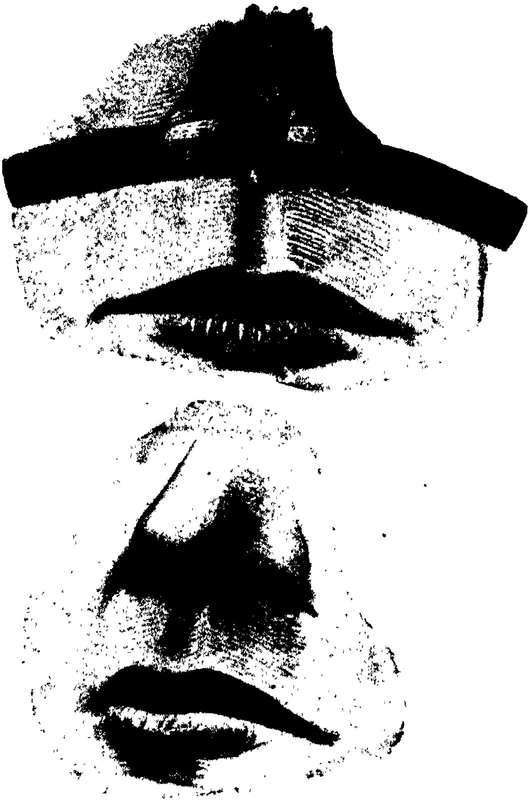

Fig. 792.—Formation of alæ and columella from long inturned flaps. The alar portions of the flaps supported by previously implanted strips of cartilage.

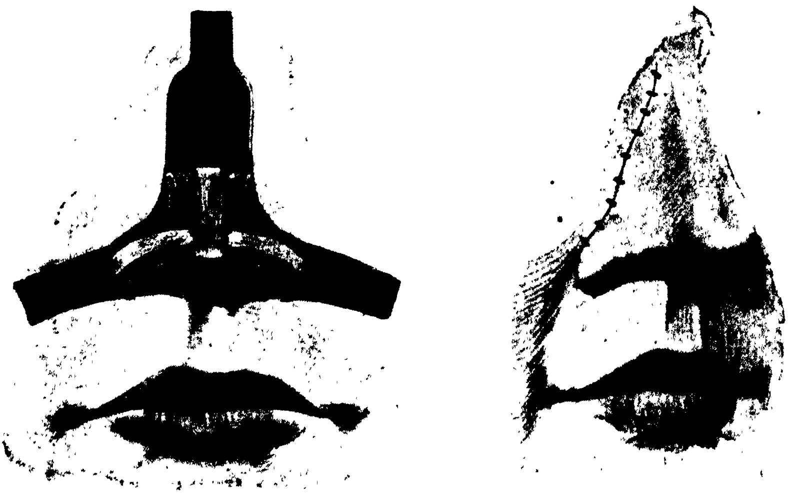

Fig. 793.—Reconstruction of columella partly from inturned flap and partly from covering forehead flap.

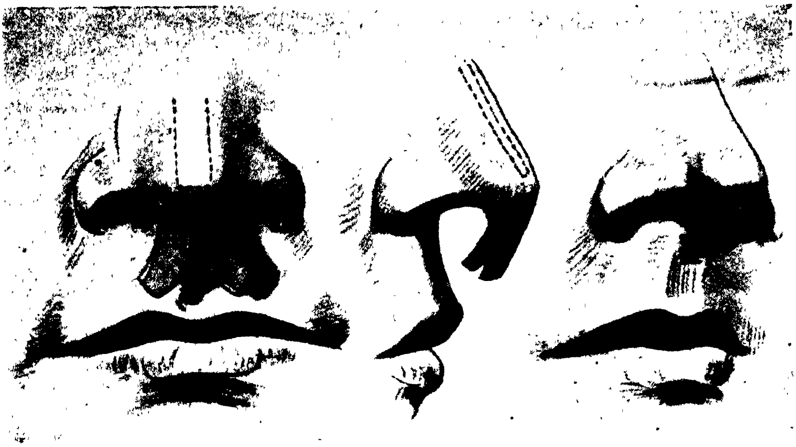

Fig. 794.—Reconstruction of columella from forehead flap.

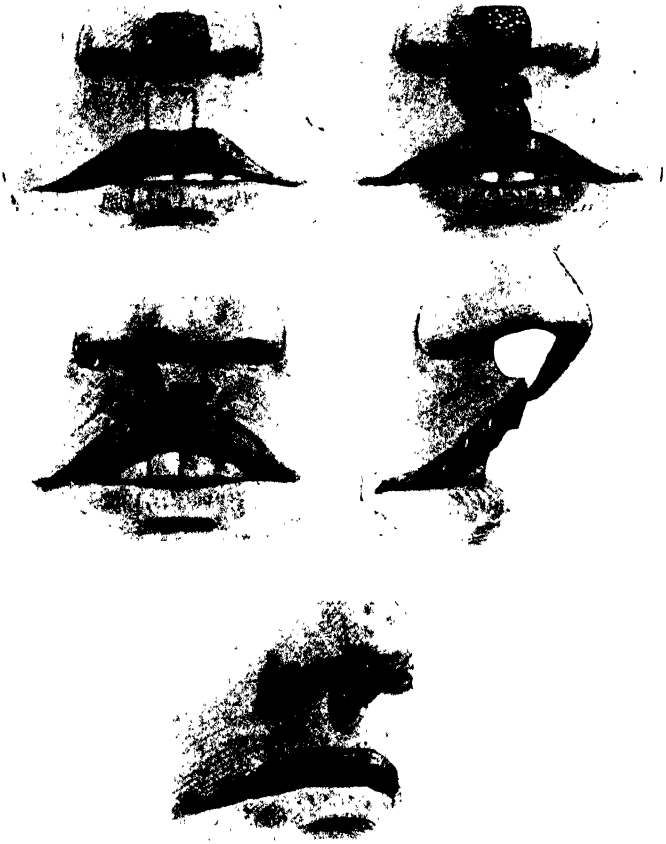

Fig. 795.—Reconstruction of columella from upper lip.

That portion of the flap destined for the nose itself should be cut of such a thickness that it reaches into the subcutaneous fat only. In special cases, where a thicker nose is required, aponeurosis and muscle may be raised. The pedicle portion should always extend down to the aponeurosis. The flap is now swung down and accurately sutured to the margins of the raw area, which have been sparingly undercut in preparation. The raw surfaces left by the raising of the alar lining

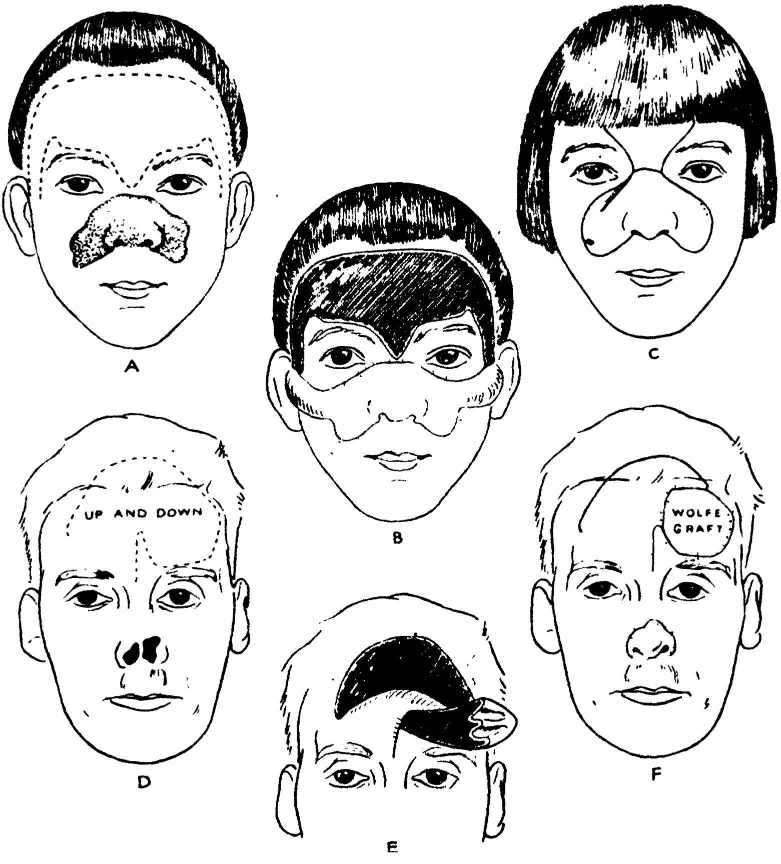

Fig. 796.

A, B, C, use of forehead on two pedicles to re-make nose and cheeks. D, forehead rhinoplasty. Up and down method (Gillies). E, folding in forehead extremity to form nostrils and columella. F, forehead grafted after return of pedicle.

flaps are closed by approximation of their edges. No tubes or othe supports are introduced, for it has been found that, instead of mair taining the airway, these tend to produce ulceration and consequen stenosis. A smearing of sterile liquid paraffin over the suture linf in the region of the alæ has been found of great advantage in preventin crust-formation. Any bleeding vessels in the raw surface on th forehead are ligatured, and the wound is dressed with a free razor gra which should be carefully arranged so as not to press upon the point of turning of the pedicle. In many cases the pedicle can be " let in " in the glabellar region : in other cases this area is closed by approximation, and the pedicle " tubed."

Stage 4.—After a minimal period of two weeks the pedicle may be returned to its position on the forehead. This procedure requires no description beyond saying that the portion of the pedicle adjoining the flap is divided in an inverted V-shaped manner, and that any granulation tissue which has formed on the forehead in the region to which it is to be replaced is excised.

A minor plastic rearrangement will be called for in which the upper portion of the flap is made to lie snugly in the area between the eyebrows.

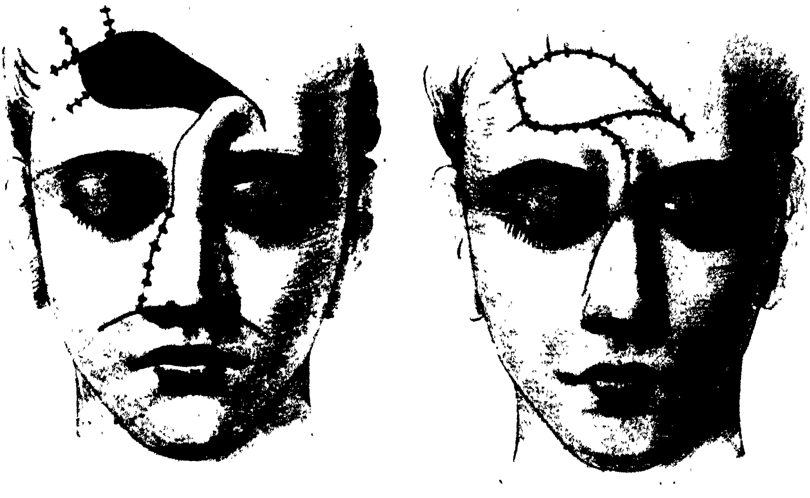

Fig. 797.—**Rhinoplasty, later stages.**

A, Forehead flap sutured in position over lining and supporting cartilages. B, Pedicle of flap returned to forehead. Remainder of raw surface covered by Wolfe skin-graft.

Stage 5.—The free razor graft mentioned above may be replaced by a Wolfe graft, cut usually from the upper limb, and sutured in position on the forehead by a carefully-applied continuous stitch. This procedure may form part of Stage 4, but it is better, if possible, to leave it until now in order that the graft may have four, instead of three, vascular margins to which it may be sutured. Any minor trimming operations in the alar region are then carried out, and a piece of cartilage from the store, suitably shaped, is inserted from above, after careful undercutting of the flap, in order to give the final contour desired.

A flap based on the superficial temporal artery has distinct advantages in the treatment of female patients, for the whole of the

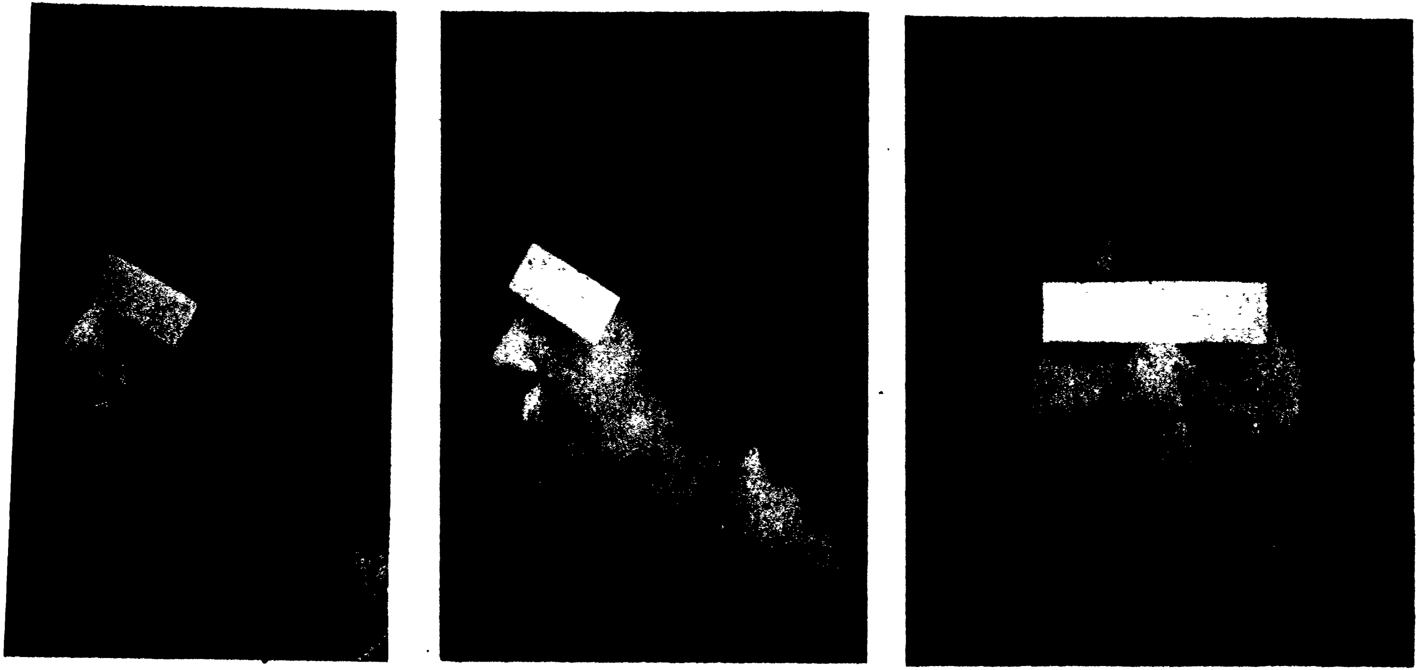

Fig. 797 D, E, F.—Partial destruction of nose following lupus. Rhinoplasty by forehead flap based on the superficial temporal artery. Photograph shows how readily all scarring is hidden by suitable dressing of the hair.
(*Gillies: Plastic Surgery of the Face.*)

scarring which it produces can be easily hidden by suitable dressing of the hair (Figs. 797, D, E, F). It is also used of necessity when the central part only of the forehead is available.

SKELETAL DEFORMITIES OF THE NOSE

Depression or asymmetry of the skeletal portions of the nose may occur as the result of congenital deformity, disease, or trauma. Care must be taken not to undertake any plastic repair during a period of active disease.

Depressed fracture of the nose.—One of the most common accidents, both on and off the road, is depressed or lateral-displaced fracture of the nasal bridge. This type of injury shows little or no loss of the supporting structures. If the case is seen any time in the first three weeks after the accident, the nasal arch can usually be manipulated into normal position. Too much emphasis cannot be laid on the necessity of giving the patient general narcosis. The evipan type is very suitable, if an extensive wound need not be repaired at the same time. Using Walsham's forceps for the sides of the arch and Ash's forceps for the septum, both the dislocation of the latter and the impaction and displacement of the nasal bones can be rectified, and septum and bones manipulated into position. It is well to fit over the replaced nose a small mould of dental composition over which a piece of malleable lead plate is fixed. This should be worn for two or three days to prevent excessive swelling and to maintain the position.

Restoration of the nasal bridge is indicated when there has been actual or potential loss of the bony and cartilaginous make-up. This often occurs after very heavy septic compound fractures, dish-face deformities, specific ulceration of the mucous membrane and bone, and submucous resections that have been unfortunate enough to produce a defect in the contour. For all these conditions except the syphilitic nose the treatment *par excellence* is the insertion of a new nasal bridge. In a previous edition it was stated that a hinged costal-cartilage graft was the method of choice. As will be observed from the notes on cartilage and bone-grafting, it has been abundantly proved that many cartilage grafts undergo subsequent bending, and that none of the defects of cartilage grafts are evident with bone-grafting. The operation of choice, therefore, is that of super-imposing above the existing nasal arch an adequate rod of bone from the iliac crest, shaped to meet the needs of the individual case. As, in the majority of cases, bony union actually occurs between the bone graft and the nasal bones, the support to the tip is quite adequate without the addition of a hinged columellar support. This simplifies the operation and, therefore, the skin incision need only be made vertically through the skin of the columella. This gives a direct approach and makes the incision very easy to suture afterwards. The method of taking the bone-graft from the crest of the ilium has already been mentioned and is quite straightforward. Considerable thought should be given to the exact shape of the bone-graft for the individual case.

Pre-operative preparation.—The nose is prepared for the operation by cutting short all hairs to be found in the skin of the vestibule. After careful removal of all crusts, the nares are packed, on the evening before operation, with small plugs of wool or gauze soaked in flavine solution. At the time of operation the nares are again carefully and gently swabbed out with small pledgets of gauze soaked in ether. They are then wiped over with surgical spirit.

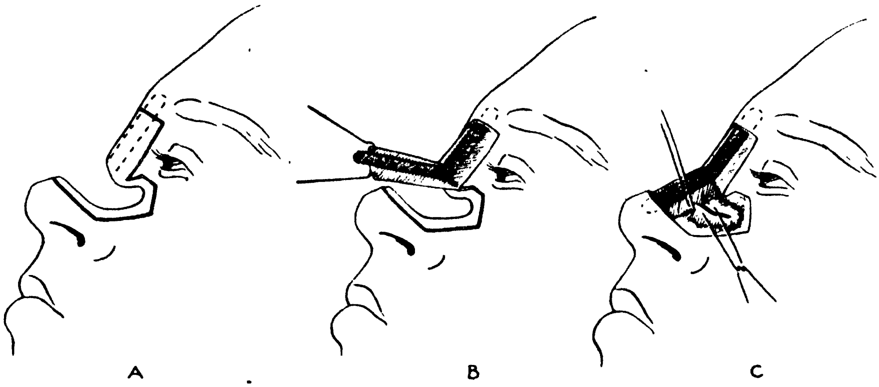

Fig. 798.—Central defect of nose.

A, implantation of small rod of cartilage. B, C, details of formation of lining membrane of missing portion by inverting skin flaps.

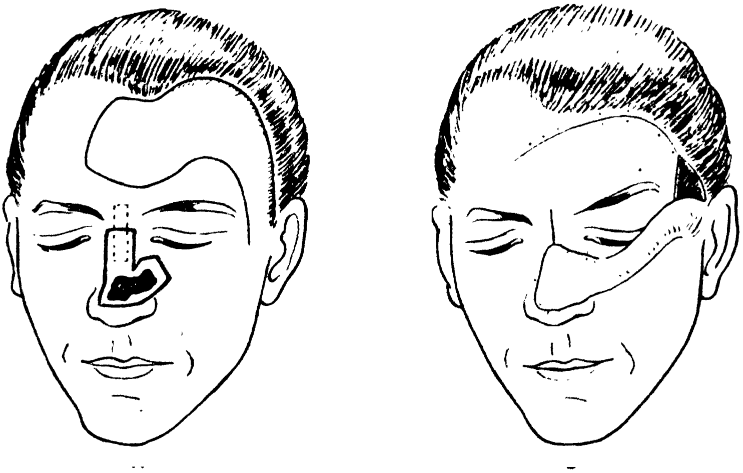

Fig. 799.

A, cartilage rod turned down with the upper flap. B, outside defect covered by curved temporal artery pedicle flap.

Operative technique.—The columella is grasped between the finger and thumb, and a small-bladed No. 15 Bard Parker knife makes the incision in the midline separating the two mesial crura of the alar cartilages. The two layers of the septum are carefully divided until the superficial aspect of the bone is reached, when the periosteum is elevated or removed by small rugines and a pocket made in the glabellar region underneath the periosteum. (Figs. 798 and 799.) The surface of the bone has now to be filed or chiselled in order to expose some of the medullary portion and to make a good platform on which the bone-graft can sit. The bone-graft, having been obtained from the iliac crest, is now inserted and the wound closed. The length of the bone-graft will usually need to be about 1¾ in. and it must be very thin where it overlies the nasal bones and thicker opposite the deepest part of the depression. It should then tail off into a thin strip towards the tip of the nose, and should not be carried to the extremity. X-ray and photographs of a bone-graft which united with the nasal bones are shown in Fig. 800.

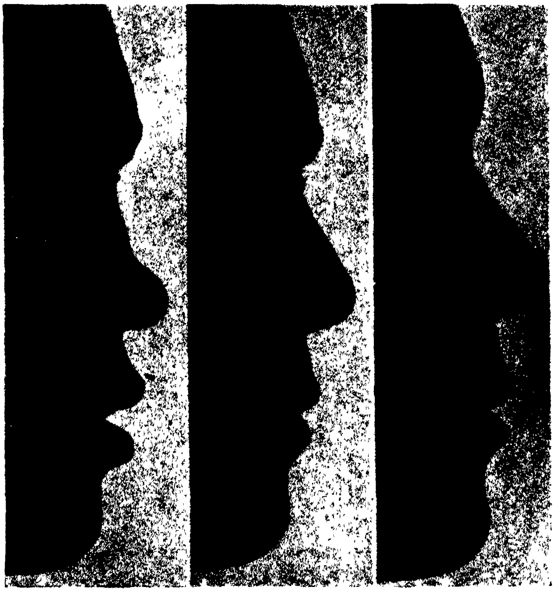

Fig. 800.

A, impacted depressed fracture of nasal bones. B, result of insertion of iliac bone graft. C, X-ray showing bony union.

Syphilitic nose.—Care must be taken not to confuse the deformity caused by syphilitic ulceration with that of an ordinary depressed nasal bridge. The difference lies in the recognition of the tissue lost. In syphilitic nasal conditions there is a concomitant loss of mucous membrane as well as of bone and cartilage ; consequently if the surgeon is tempted to insert a bone-graft only, the result will be extremely disappointing. Provision must be made for the missing mucous membrane. The real loss is not apparent until the skin and soft tissues of the tip have been freed from their vicious attachment to the maxilla. Thus, an incision is made in the upper buccal sulcus, deepened until the nasal cavity is penetrated, and carried on laterally on each side as far as the glabella. Then the whole shape of the nose becomes apparent, as there is no loss (normally) of the external skin. On further examination, a large raw area will be found on the under-surface of the skin and lateral portions of the nose. This must be skin-grafted by the dental-splint pressure method already described. The skin-graft must be maintained at full stretch for three months, when the dental appliance may be discarded and a bone or cartilage graft inserted in the bridge-line between the external skin and the newly implanted internal skin-graft. This operation is a most dramatic and successful procedure. Alternatively, the temporary dental appliance may be modified by the dental surgeon and used by the patient as a permanent support, in which case only one operation is needed. (Fig. 801.) Full details of the treatment of this defect can be read in papers already published.*

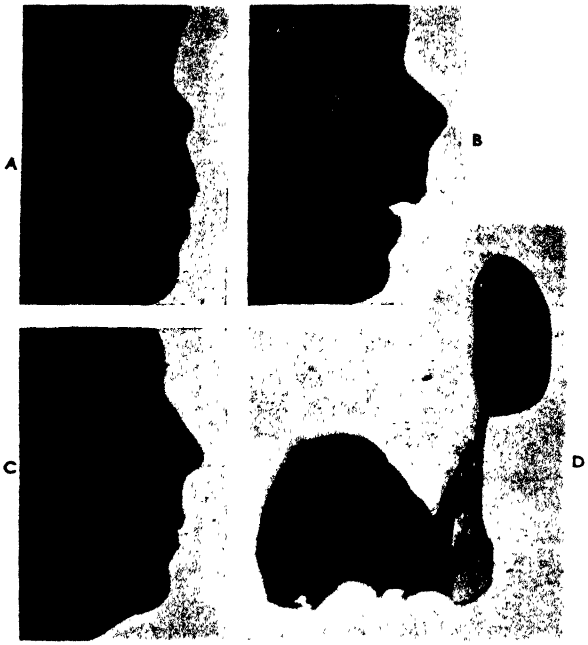

Fig. 801.
A, specific ulceration of nasal mucous membrane. B, preliminary overdistention. C, result of treatment by skin inlay. D, permanent dental prosthesis by Mr. F. A. Walker, London.

PLASTIC OPERATIONS ON EYELIDS AND EYEBROWS

In cases in which the whole of an eyelid has been destroyed, the result of any plastic operation is likely to be far from pleasing, for almost invariably the new lid which can be made remains thick, heavy, and lifeless in appearance. When, however, the loss of the lid-edge is limited to one-third or less of the whole, a very satisfactory repair can be made.

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* " Deformities of the Syphilitic Nose," *Brit. Med. Journ.*, Nov., 1923, ii, 977, and *Dtsch. Z. Chir.*, Feb. 23, 1938, ccl, 379.

The operations described in this section apply only to cases in which the eye itself has been lost, for it is seldom that the surgeon will be called upon to reconstruct an eyelid where a normal eye remains. Here, again, the principle of *restoration in kind* must be emphasized.

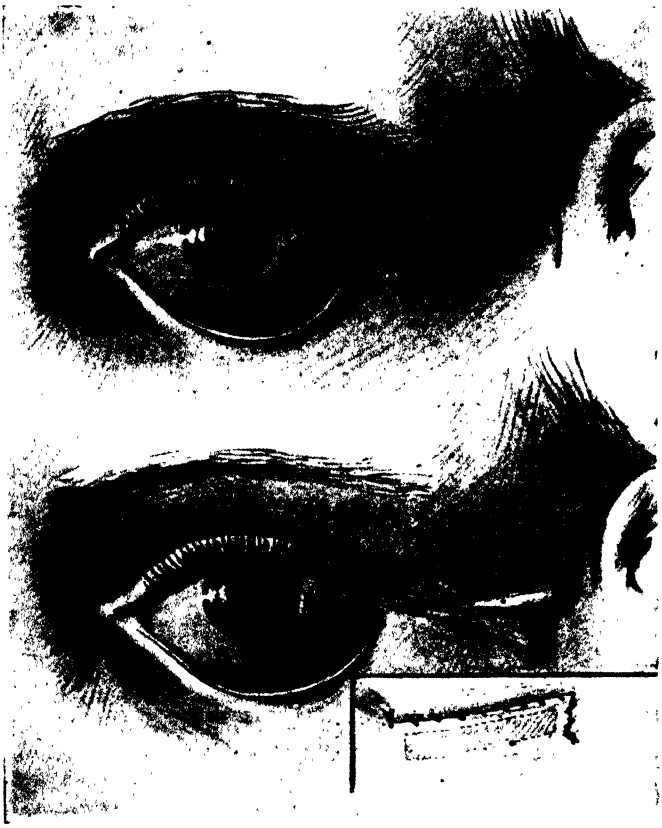

Fig. 802.—Reconstruction of lower eyelid : first stage.

Above, incision for implantation of thin flake of cartilage. Below, flap undercut and cartilage implanted. Inset, flap returned over cartilage implant.

Figs. 802 and 803 illustrate a typical reconstruction of the lower lid. The operation is divided into two stages : (1) Cartilage from the ear or from the ribs, of a suitable length and thickness, is inserted subcutaneously beneath the site of the proposed flap, extending outwards from the external canthus. After a minimum period of ten days a combined skin-cartilage flap is raised and swung inwards, the skin forming the lining of the new lower lid and the cartilage now lying on, and being adherent to, its anterior aspect. The lower border of the skin is carefully sutured to the upper edge of an incision made along the lower margin of the conjunctival remains, and in this way a new lower fornix is completed. (2) The raw surface now remaining may be dealt with in one of the following ways :—

(*a*) The outer part of the wound may be closed by approximation, and the lid portion Thiersch- or Wolfe-grafted.

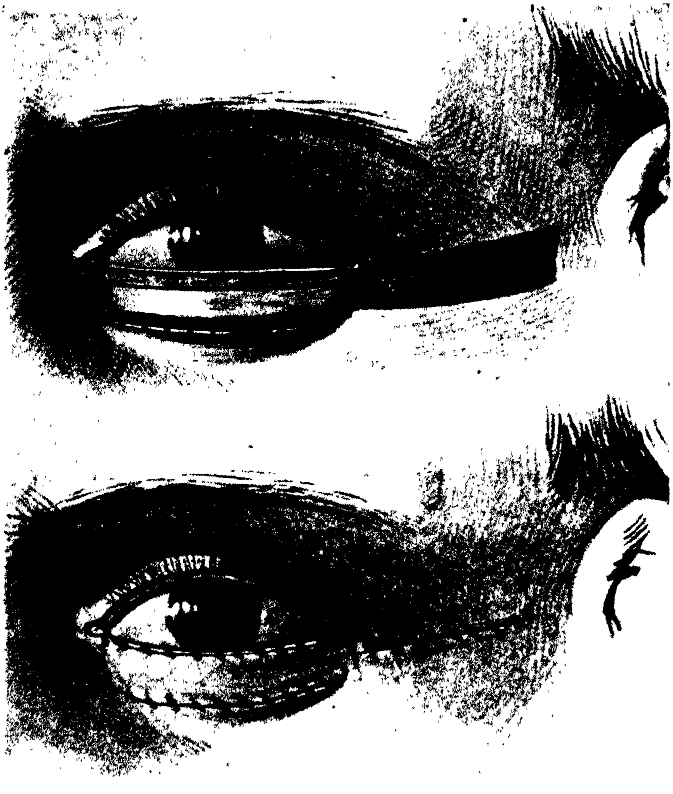

Fig. 803.—Reconstruction of lower eyelid : second stage.

Above, cartilage-bearing flap inturned for lining of new lid. Below, area from which inturned flap has been taken closed by approximation. Covering skin for eyelid obtained by free skin-graft (Wolfe variety).

(*b*) A descending temporal flap may be swung down to cover both defects.

(*c*) A flap may be brought up from the cheek.

(*d*) A double pedicled flap may be taken from the upper lid (Tripier). (Fig. 804.)

(*e*) Skin may be conveyed to the lid by a tubed pedicle from the neck.

When a live eye is present, mucous membrane must be on that portion of the reconstructed lid that will be in contact with the globe. If any skin is used minute hairs will grow and irritate the eye.

Eyebrows may be provided by transposed temporal artery scalp-flaps. The extremity of the flap should be composed of a curved piece of skin of suitable length, and having the hairs growing in the correct direction. A much more satisfactory way is to cut a thin curved strip from the scalp in the mastoid region of the same side, and to sew this hairy graft in to form an eyebrow. Not all the hair follicles survive (Fig. 805).

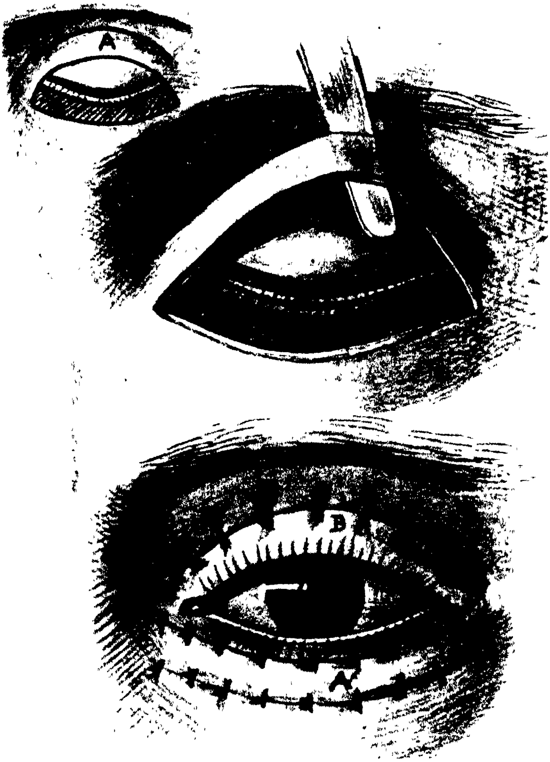

Fig. 804.—Reconstruction of lower eyelid by double pedicled flap from upper eyelid. (*Tripier.*)

TEMPORAL MUSCLE SWINGS

In those cases of injury in the vicinity of the eye in which the chief disfigurement is due to the loss of prominence in the malar and infraorbital regions, the temporal muscle swing operation has proved of great service.

After excision of scars and general re-arrangement of skin in the flattened area, a U-shaped flap is turned down from the temporal region, and the temporal muscle exposed. The anterior one-third to one-half of the muscle, together with its overlying fascia, is detached from its origin and freed well down towards the coronoid process of the mandible. The fascial attachment to the remains of the zygoma must also be carefully divided.

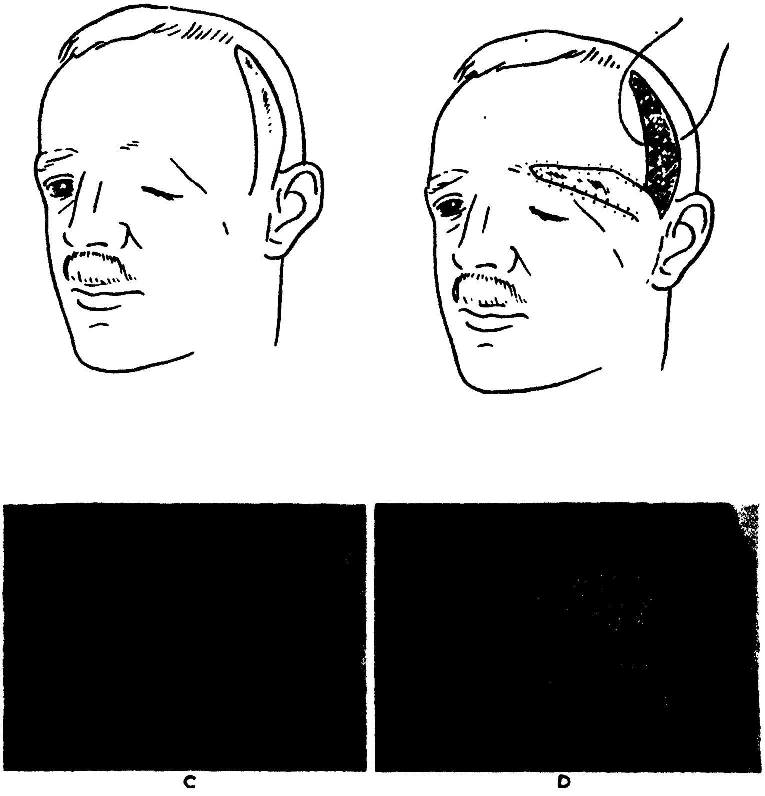

Fig. 805.

A, B, pedicle graft method of making eyebrow. C, D, hairbearing dissected graft: C, before operation. D, after operation.

The free extremity of the muscular flap thus fashioned is passed under the bridge of skin separating the two operation areas, and given a new origin in the region of the upper part of the maxilla, where it is anchored by deep sutures to the periosteum. The blood and nerve supply are not apparently seriously interfered with, for in the majority of cases the transplanted muscle can be made to contract, and gives a very colourable imitation of the action of the orbicularis oculi, which is usually paralysed from the associated upper facial paralysis.[*]

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[*] Details of this operation will be found in *St. Bartholomew's Hosp. Journ.*, May, 1917, xxiv, 80. *See also* p. 1643.

CICATRICIAL ECTROPION*

This disfiguring disability, the most important and constant sequela of facial burns, has shown itself particularly amenable to treatment by the procedure known as the " epithelial outlay," based on the Esser skin-graft.

An incision is made immediately external to the ciliary margin, and extending completely across the area involved, usually from canthus to canthus. Gentle traction on the lid margin being maintained, the incision is gradually deepened until the lid edge can be brought into an over-corrected position. The musculature of the eyelid should be damaged as little as possible. A small mould of dental-modelling composition is made of such a size and shape as to lie snugly in the raw surface and allow the skin-edges to be approximated over it. A small, thin, hairless Thiersch graft, taken usually from the arm, is wrapped round the mould in such a way that its two free edges meet on the anterior aspect. The graft-covered mould is placed in position on the raw surface, and horsehair stitches are passed from skin-edge to

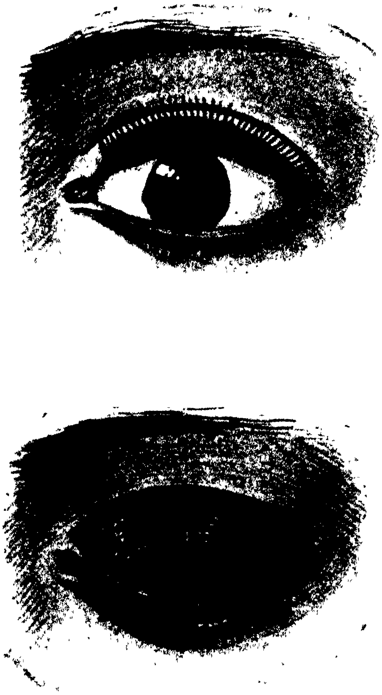

Fig. 806.—Operation for cicatricial ectropion.

Above, incision from canthus to canthus freeing lid margin. Below, lid margin brought into over-corrected position by dividing all scar-tissue bands.

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* *See also* p. 1344.

skin-edge, picking up the free edges of the graft on either side. The mould is thus buried, and the ectropion is reproduced, and may be even exaggerated for the time being. The after-treatment consists in keeping the eye clean by frequent irrigation and removing crusts from the wound. Nothing further is done for ten days, when any sutures which have not already cut out are divided and the mould is discarded. The eyelid now falls into a normal position, and its outer surface is invariably found to be completely epithelialized. From this time onwards the cosmetic result rapidly improves, the somewhat hollow appearance following the removal of the mould becoming smoothed out in a comparatively short time. Gentle daily massage after the application of a little sterile liquid paraffin expedites the latter process. Rarely, a certain amount of minor trimming at the margins of the graft is required. Figs. 806–7 illustrate the various stages of this operation.

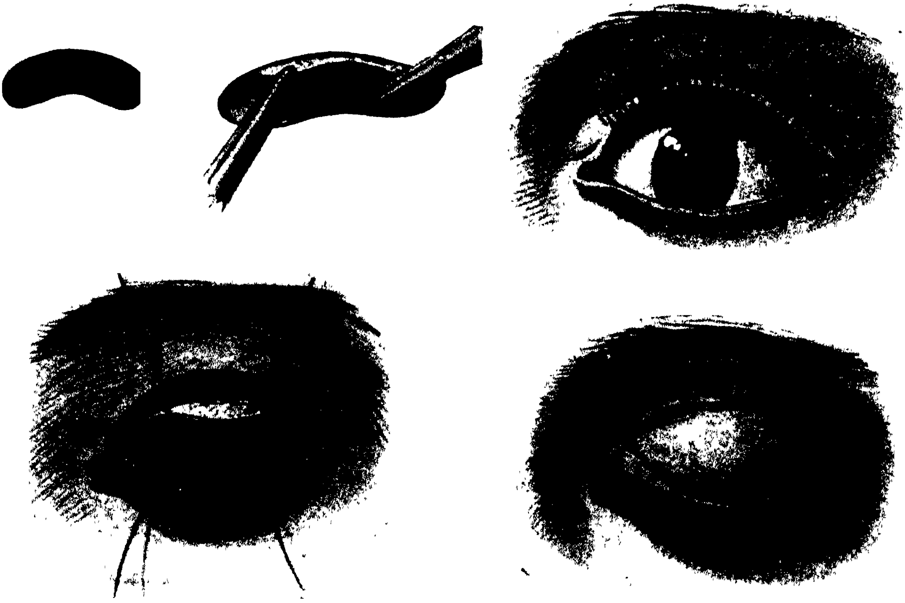

Fig. 807.—Operation for cicatricial ectropion.

A, Above, mould of dental composition. Thiersch graft being wrapped around mould. Below, mould and graft in position, showing main sutures piercing graft and margins of raw surface.

B, Above, mould and graft completely buried. Below, result of grafting.

Although this buried method of applying the graft is a very definite and pleasing process, the method is now generally modified by applying the mould superficially without any stitching. The graft is applied to that part of the mould in apposition to the raw area and the mould and graft are fixed by suitable dressings (*see* Skin-grafting,

p. 1638). Occasional stitches are used to unite temporarily the upper and lower ciliary margins and prevent lid movement.

This modification is easier to perform and gives quite perfect results almost from the start. The graft need not be cut especially thin.

Wolfe graft for cicatricial ectropion.—In minor degrees of ectropion a free graft of eyelid skin from the opposite upper lid gives a most perfect result. The whole-thickness skin is used and sutured into place according to the principles outlined under the section for Wolfe grafts (p. 1640). In larger defects an excellent graft for the lids is obtained from the skin on the back of the ear. This is usually of good colour and flexible. The suture of the skin at the back of the ear gives little trouble ; the posterior margin should be undermined. The best stitch for the skin-edges is a subcuticular one which is put in while the ear is held forward, and when every bite for the stitch has been taken the whole is gradually tightened. There is no doubt that the successful Wolfe graft gives a better cosmetic and as good a functional result as the thick-razor graft.

PLASTIC OPERATIONS ON THE EARS

Perforations of the pinna may be closed by small flaps swung from the posterior surface and covered by skin-grafts.

Marginal losses, producing a much more noticeable disfigurement, are best treated by turning up flaps from the posterior aspect of the pinna containing previously implanted cartilage. Such cartilage may be obtained from the same pinna, or that of the opposite side, where its removal appears to cause no disfigurement, or it may be taken from the costal region in the usual way and fashioned to the required shape and size. The covering for such a cartilage-bearing flap may be obtained by skin-grafting, or by a small tubed pedicle or bridged flap from the neighbouring part of the neck.

More extensive losses are treated by implantation of suitably shaped cartilage beneath the skin of the mastoid region, and later by turning this supported flap forward into a normal position and covering its raw surface with skin-graft or skin-flap.

Congenital absence of the external ear.—So far as treatment is concerned this might be classed with extensive traumatic loss and, owing to the advent of the new method, it can be treated by surgery. The principle upon which this repair is established is that it has been found possible to graft ear cartilage from a donor, usually the mother or other female, into the non-hairy portion of skin in the neighbourhood of the missing ear, usually behind it. The maternal ear-cartilage is grafted as the first stage after the skin has been superficially undermined. At the end of three months all the shapes and hollows of the maternal ear will be showing through the skin under which it has been placed. (Fig. 808.) An incision is then made round the circumference of this implanted cartilage, which is turned forward into the position of the new ear, together with its skin covering. The raw surface so caused comprises that on the posterior part whence the flap has come, and the posterior surface of the new ear itself. This is either skin-grafted direct or repaired by a tubed pedicle flap previously prepared from the acromiopectoral region. This method has made a complete revolution in the principles and results of making a new external auricle.*

Adhesions of pinna.—Cases in which the disfigurement consists entirely of adhesion of part or all of the pinna to the mastoid region, a frequent sequela of severe burns, may be treated by freeing the pinna and Thiersch-grafting the raw surfaces of the pinna and mastoid region by grafts applied on a suitable mould.

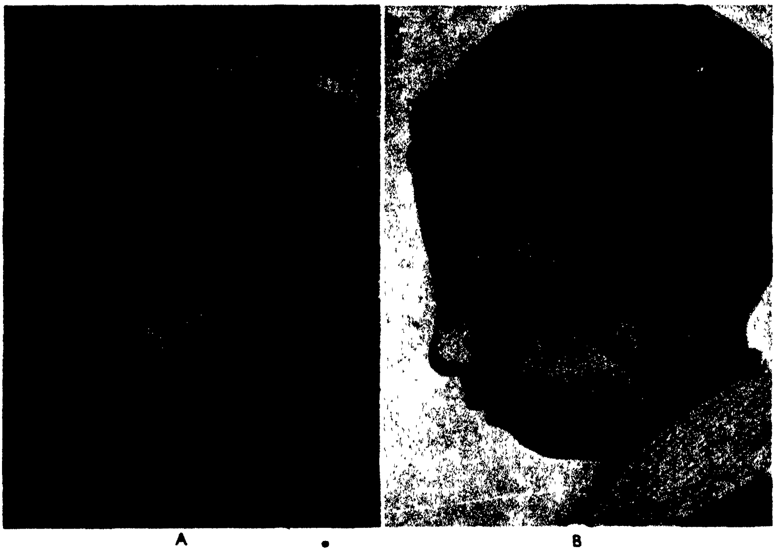

Fig. 808.
A, congenita absence of external ear. B, same case after grafting of maternal ear cartilage before final plastic which consists of joining the lobule, turning the new ear forward and skin grafting the posterior aspect.

Undue prominence of ears may be reduced by suitable elliptical excision of skin and cartilage by incisions on the cranial aspect of the pinna, followed by simple approximation by suture.

PLASTIC OPERATIONS ON THE LIPS

Repairs of the **upper lip** call for the provision of skin-covering, muscular and subcutaneous tissue, mucous-membrane lining, and vermilion border. In the male subject it is better, if at all possible, to provide a skin-covering which shall be hair-bearing.

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* Gillies, "Reconstruction of the External Ear with special reference to the use of maternal ear cartilage as the supporting structure," *Rev. Chir. Structive*, No. 3, Oct., 1937, iii, 169.

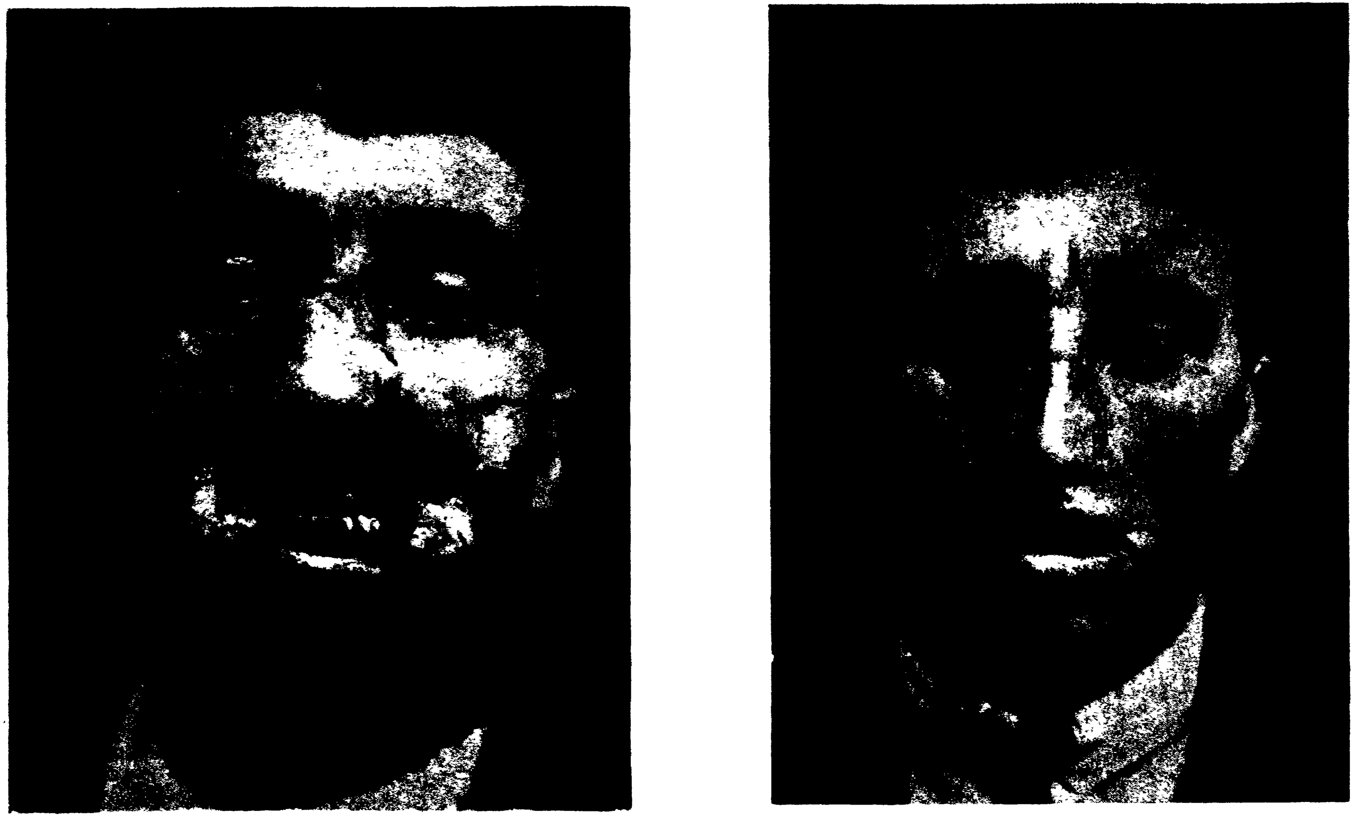

Fig. 809.—Complete loss of upper lip treated by turning in, from the immediate neighbourhood of the defect, skin-flaps for lining and mucosal flaps for vermilion border. The covering skin was provided by ascending flaps from the lateral aspects of the chin. (*Gillies's "Plastic Surgery of the Face.*")

The methods advocated are four:

1. **A single or bilateral ascending flap of full thickness** (i.e. composed of skin, subcutaneous tissue, muscle, and mucosa).—Such a flap in the male is hair-bearing and, though much of its blood supply must be destroyed by the division of several of the main branches of the facial artery, its vitality has usually proved satisfactory. It is particularly apt to produce a depression of the angle of the mouth, requiring a secondary operation for its correction, but on the whole the results are satisfactory.

2. **Descending flaps from the lateral nasal region.**—These again may be made of full thickness in part of their extent, but they have the disadvantages that their length is naturally limited and that they bear no hair. In their favour, however, are the facts that they contain well-marked branches of the facial artery, and hence have a particularly good blood supply, and that they have not the same tendency as the flaps in the first method to produce depression of the angle of the mouth.

3. **A hair-bearing flap brought down from the forehead or temporal region on a tubed temporal-artery pedicle.**—In this method the lining must be obtained from the immediate neighbourhood of the defect, either by turning in skin-flaps or by swinging mucosal flaps from the inside of the mouth. Fig. 809 illustrates a case in which the latter part of this procedure was carried out, the covering flaps, however, being obtained from the chin. In cases where hair-bearing skin is not required, both lining and covering may be brought from a more distant part of the body, where subsequent scarring may be easily hidden, by means of the tubed-pedicle flap.

In all cases it is necessary to guard against providing a lip deficient in length from side to side, for the disfigurement produced by such a flattened or tightened upper lip is very serious.

For minor losses, simple advancement operations or the combination of local flaps and skin-grafts may suffice. Vermilion margin is best obtained from the opposing lip or cheek. For the transfer of mucosal vermilion border from upper to lower lip, a small flap is turned down and stitched in position on the surface prepared to receive it. The lips are fastened together in such a way as to allow space for feeding the patient, and after a period of ten days the bridge is divided and the mucosa re-arranged on both lips. It is surprising how little the lip which may be called the donor suffers in this procedure by the loss of quite a considerable flap.

4. **Abbe's operation** consists of taking a triangular whole-thickness wedge out of the lower lip, to fit, when turned upside down, into a gap in the upper lip. It is kept alive on one coronary vessel and a tiny pedicle. The results are strikingly good, and give a pleasant everted upper lip. This operation is especially applicable to severe double hare-lip cases.

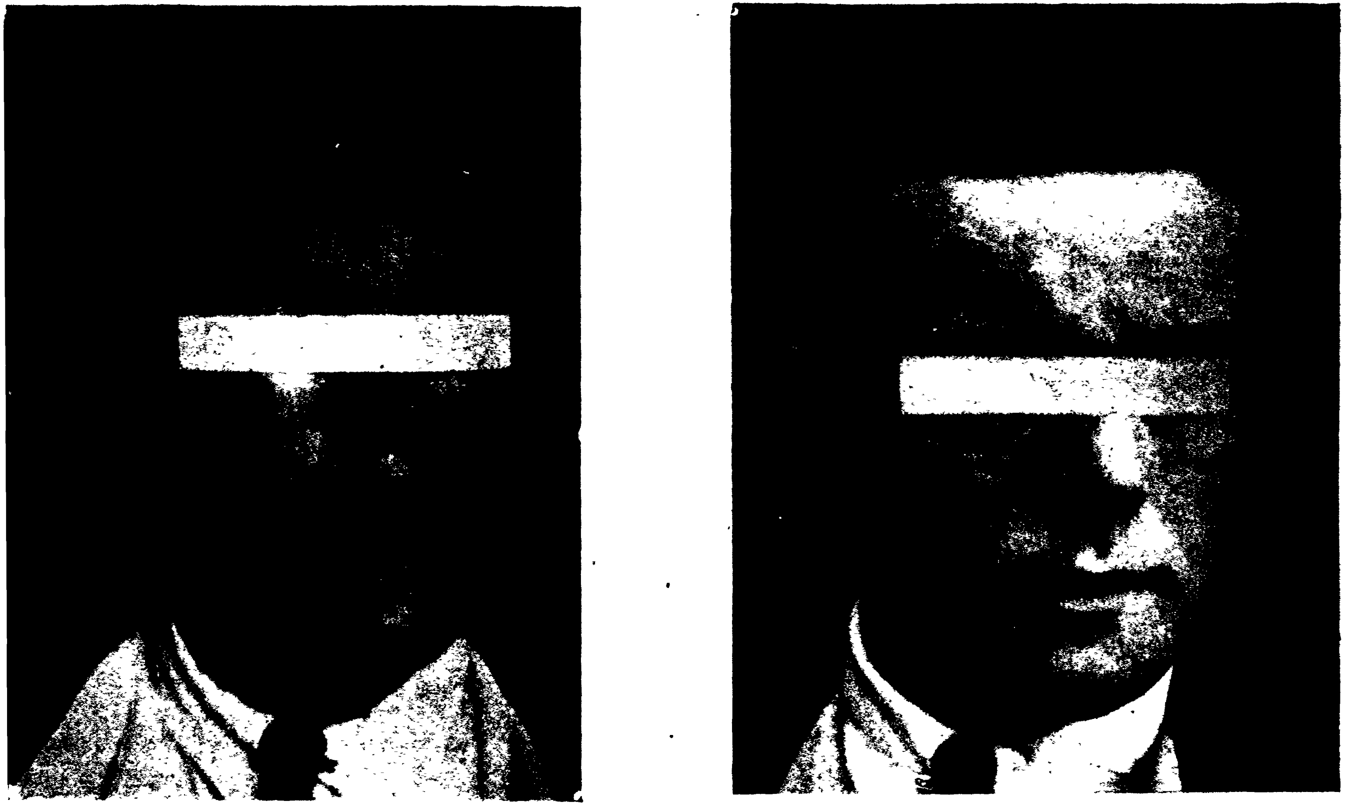

Fig. 810.—Repair of loss in lower lip and chin by simple advancement flaps, swung upwards in V-Y fashion, after excision of all scar tissue. (*Gillies "Plastic Surgery of the Face."*)

Small losses in the **lower lip,** not extending to more than one-third of the whole, may be repaired by simple advancement methods requiring no special description (Fig. 810).

More extensive losses may be made good by descending full-thickness flaps, by ascending inframandibular flaps of the "vertical-to-horizontal" type, or by tubed-pedicle flaps from a more distant part of the body. In the very extensive losses affecting the whole of the chin region, the lining membrane is usually obtained by inturned flaps from the margins of the defect. These usually carry hair-follicles, and the growth of hair into the mouth may prove troublesome. It must be remembered, however, that it is easy to get rid of this trouble at a later stage by Thiersch grafting when the tissues of the new chin have become established.

For very large losses the forehead skin, swung down on both temporal arteries, makes a very satisfactory covering. Later on, it is possible to reconstitute the bony framework of the chin, replacing the missing portion by a suitably shaped bone-graft from the iliac crest or the tibia. An osteo-periosteal graft obtained from the tibia may be curved to a nicety, and is therefore particularly useful.

In plastic operations in the region of the lips, except where repair can be carried out by local musculo-cutaneous flaps, it is difficult to avoid producing thick, lifeless-looking masses which give a poor cosmetic result and add very little to functional efficiency. It should be added that the previous preparation of a suitable prosthesis is of the greatest help in all these cases, in that it provides a scaffolding over which the new tissues may be built.

HARE-LIP*: OPERATIONS FOR THE CORRECTION OF SECONDARY DEFORMITIES

The object of operations for hare-lip is the removal of the cleft lip stigma. The surgeon should only be satisfied when the lip and nose reveal no sign even of good repair. The observer should think no more of the patient's lip than that there had been a slight accident to it some time (Fig. 811). But the original deformities of the nose and lip are often so complex that it is unreasonable to expect any one operation, undertaken as it is at a very early age, to accomplish more than an aseptic closure with simple adjustment. This produces a sound basis for future cosmetic work, and the surgeon should be able to employ other procedures, such as have been recently described by Gillies and Kilner, in order to free his patient from any vestige of hare-lip stigma.

These operations are directed towards :—

(*a*) The readjustment of general contour.
(*b*) The readjustment of the lip.
(*c*) The readjustment of the nose.

General contour.—The commonest contour deformity seen in old hare-lip and cleft palate cases is produced by flatness of the lip and depression of the nose. It is obvious that the flat lip is caused by a lack of forward projection in the underlying maxilla, most marked when the premaxilla has been removed, but present in a lesser degree in a large proportion of lips which have been constructed over complete alveolar clefts either bi- or uni-lateral.

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* *See also* Chap. xxxv, p. 1607

The operative procedure most widely applicable to this type of lip and nose has been called the buccal inlay, and consists of the introduction of a Thiersch graft on a mould designed to free the lip and nose from the underlying retroposed maxillæ. Freeing and loosening the lip in this way allows an upper denture sufficiently prominent to produce normal contour and carrying, well in advance of the existing position, artificial teeth which articulate normally with the lower teeth.

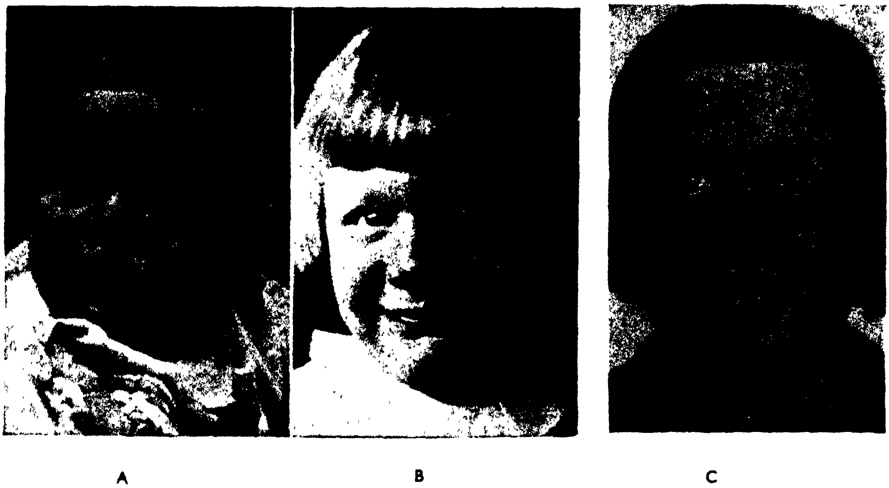

Fig. 811.

A, hare-lip at six months of age. B, same case three years and ten months old. C, Same case seventeen years old.

Technique of buccal inlay.—The dental appliance is prepared beforehand and should consist of a simple metal cap splint fixed to the existing teeth and carrying a small adjustable tray in front to support the moulding material used to build forward the lip and carry the Thiersch graft.

General anæsthesia by the intratracheal method of Magill is used, and the pharynx is packed off so that there is no communication between the upper air-passages and the field of operation. An incision is made along the upper buccal sulcus penetrating the nasal cavity and is carried laterally over the surface of the maxilla on each side to a greater or lesser extent, according to the backward displacement of the nose. The extent of lateral undermining depends on the degree of nasal displacement. As the tip of the nose is usually dragged down and back, scissors are passed through the mouth incision and, with one blade in each nostril, the membranous part of the septum is progressively divided until the nose tip comes forward and upward to the desired position. Next a piece of Stent's modelling compound steeped in boiling water is taken and moulded between the lip and the nose in front and the maxilla behind, care being taken to prevent any excess passing into the nasal airways. The tray of the splint is fitted and the mould adjusted to it and manipulated to produce an exaggerated edition of the desired contour. The mould is set by dripping iced water over the parts, and is then removed with the tray. After being dried, it is held by an assistant to receive, raw surface outwards, the Thiersch graft previously cut from a non-hairy part of the body. When the one-piece graft has been stretched evenly over

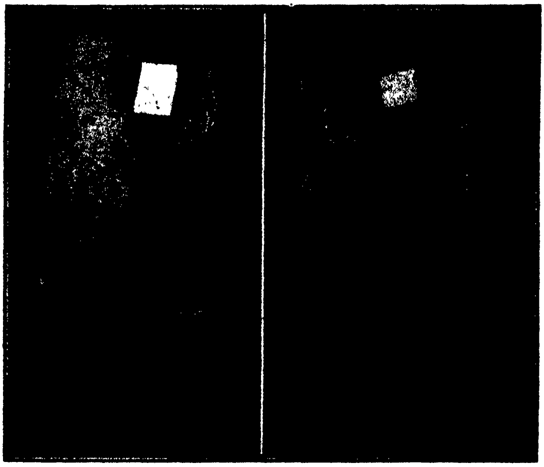

Fig. 812.—Buccal inlay, showing resultant change of contour.
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those parts of the mould which come into contact with raw surfaces, the whole contrivance, graft, mould and tray, is pushed back into position and the operation terminated by tightening the screw which holds the tray to the splint. Fixation of the upper lip by mastisol strapping is advisable though not strictly necessary.

The nose and mouth are kept clean, and the mould is removed in about a week to ten days, when the graft is found perfectly adherent to all raw surfaces. Excess of graft is mopped or irrigated away, and the tray and mould are cleaned and replaced for another ten days. The patient is then handed over to the dental surgeon who replaces the mould by a new one of black gutta percha. This new mould is removed daily at first for cleansing purposes, and later, is cared for like an ordinary denture. Finally, the dentist fits a comparatively simple upper denture, hiding the malplaced upper teeth, blocking the oro-nasal communication, but leaving the nasal airways free, pushing forward the lip and nose-base, and bearing teeth occluding normally with the lower ones. Fig. 812 shows the result of this simple procedure.

Re-adjustment of the lip.—Several problems present themselves in dealing with the lip. These are concerned with the malposition of the prolabium producing depression of the tip of the nose, the lip scar itself, and the lip margin.

One of the commonest cosmetic faults is found in cases of double hare-lip, for the so-called prolabium is often placed so far down the lip that the lobule of the nose is dragged down with it. The prolabium varies greatly in size, and only when it is fully developed can it be considered truly part of the lip and vermilion border. In most cases it represents the base of the columella only, or a lateral continuation of the skin of the sides of the columella into the floor of the nares. The mucous membrane of the premaxilla, having failed to unite with that of the advancing lateral processes, forms a pseudo-vermilion border for the prolabium, and this has tempted many a surgeon to utilize it in the construction of the new lip-margin, to the permanent detriment of the patient.

It is imperative in all cases of down-drawn nose-tip to take the prolabial skin out of the lip and suture it so high upon the free border of the septum as will allow the nose to come forwards and upwards into normal position. To ensure this, it may be necessary to divide the membranous septum with scissors, which are carried over the anterior border of the septum in order to free the parts sufficiently. The membranous septum is reconstructed later with sutures which maintain the corrected and advanced position of the columella and nose-tip. Following the removal of the prolabium from the lip there remains a V-shaped gap. The skin of the lip, the floor of the vestibule, and the base of the alæ are carefully undermined by a blunt-ended knife. This loosens the false attachments of the alæ, and a buried catgut suture is inserted to gather the deep tissue together and support the columella from below and behind. This stitch draws in the alar bases and so improves the nose still further by narrowing the nostrils ; at the same time it reduces tension on the scar which results from the approximation of the margins of the skin defect.

Little need be said about the lip scar, except to emphasize the necessity for removal of all scar tissues, accurate apposition and resuture of the muscle bundles, and careful equalization and apposition of skin and mucous membrane. The well-known Rose type of repair is to be preferred to any system of complicated flaps or incisions. To obtain a high standard of cosmesis the greatest care must be taken to avoid tissue tension and trauma, and all manipulations must be carried out with a light touch. Eyeless needles mounted on the finest ophthalmic silkworm-gut, tiny hooks rather than forceps, and sharp knives are necessary to attain these standards.

Even when the skin edges have been accurately sutured, general asymmetry of the lip margin may remain. On the other hand, the lip itself may be too long vertically, for its length from side to side, with very little vermilion border showing, and resembling somewhat the lip of an Irishman's caricature. In both instances a pleasing result may be obtained by performing the "Cupid's bow" operation. In principle this consists in discarding altogether the existing skin-vermilion junction and making a new curved lip border at a higher level. At the same time the lower band of muscle should be nicked on each side of the philtrum. The result is an attractive short lip with a full mucous membrane, and at least a suggestion of a Cupid's bow. (Fig. 813.) It should be realized that, apart from the cosmetic improvement obtained by the operation, the closure of the two elliptical or diamond-shaped defects produced by the excision has the effect of increasing the side-to-side dimensions of the lip margin, much as the Rose-type closure of a lip-cleft increases the vertical dimensions of the lip. In a few cases, happily very few, there has been so much surgical and developmental loss of tissue that nothing short of grafting a whole thickness flap from the lower lip (Abbé's operation, p. 1676) is likely to give any striking improvement.

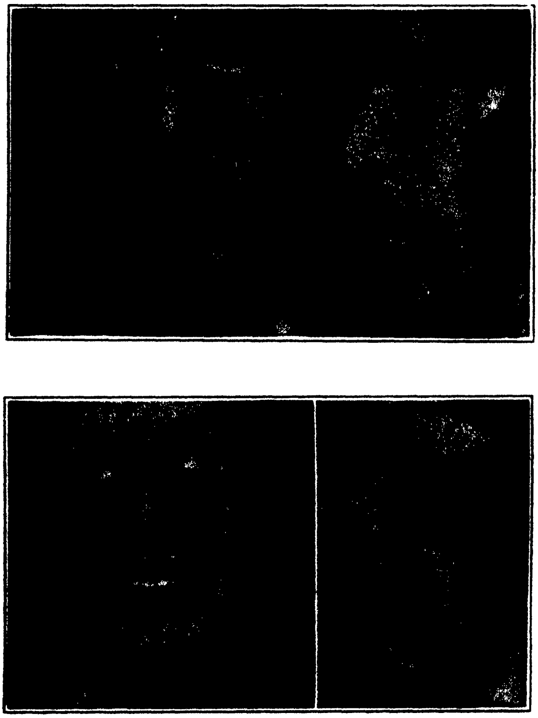

Fig. 813A.—Before operation (above), and after operation (below), illustrating the formation of Cupid's bow.

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Re-adjustment of the nose.—The relation of the depressed nose to the prolabium and the treatment of this deformity has already been discussed. In addition, however, there is frequently separation of the intercrural angles of the alar cartilages, producing excessive width of the lobule of the nose. Correction can usually be obtained by carrying out the procedure already mentioned, in which the incisions separating the prolabial skin from the lip are carried forwards on the membranous septum, freeing the mesial crura and allowing them to slide forward on the free border of the nasal septum to re-form the tip of the nose. (Fig. 813.) In more severe cases it is necessary to carry these incisions still further, to free also the intercrural angles and the anterior parts of the lateral crura. In some cases there is insufficient septal development to give prominence to the new tip, and a supporting graft of cartilage or bone is required later.

The most difficult problem, and one which has proved a stumbling block to all surgeons, is undoubtedly the correction of the flat ala. Since the structural defects underlying the deformity are gradually being made clear, however, the hope is expressed that the difficulty can be satisfactorily overcome and the nostrils made to appear symmetrical. The factors contributing to the production of this complicated deformity, when carefully analysed, include the following :

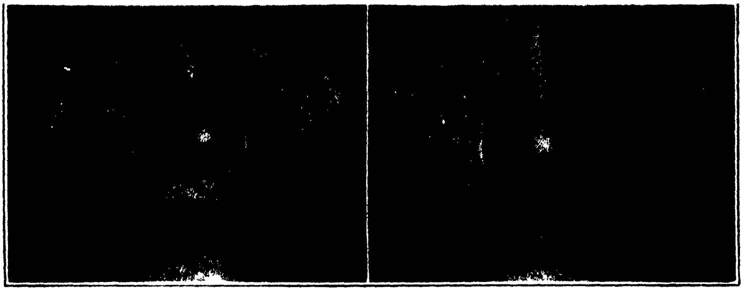

Fig. 813B.—Example of the correction of crooked nose and flat ala. Note Cupid's bow.

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(*a*) Deviation of the septum away from the flattened ala combined with lack of support to the alar cartilage due to this tilting.

(*b*) Maxillary under-development. The poor development of the smaller maxillary element results in an outward and backward drag of the ala on that side.

(*c*) Secondary distortions of the alar cartilages. The treatment of this complex deformity is difficult to standardize and each case must be judged on its merits.

Treatment.—A suitable choice of one or more of the following manœuvres is recommended :—

Straightening the nose.—The whole nose may be mobilized and set straight by osteotomy of the frontal processes of the maxillæ and of the nasal bones themselves where they articulate with the frontal bone, followed by freeing the septum from the nasal crest and spine of the maxilla. The freeing of the septum in its anterior part may usually be done submucously, but occasionally it is necessary to divide all its layers and displace it bodily before it can be persuaded to lie in the middle line. In severe cases of lateral deviation of the nose, the long side of the bony arch—that on the side of the smaller lip element—requires reduction by the removal of a wedge; if this is not done, a gap is left in the arch on the short side in the line of osteotomy when the nose has been re-set, and there is a natural tendency for the nose to become deviated again by the approximation of the edges of this defect.

Replacing the alar cartilage.—The distorted alar cartilage must be mobilized to allow it to slide forward into symmetry with its fellow, and it must be fixed in this new position by suture. When the distortion is mild in degree, the incision may be entirely intranasal, i.e. confined to the skin of the vestibule and the membranous septum. The whole of the convex surface of the cartilage (that aspect of the cartilage furthest from the vestibule) is undermined, when it will be found that the depressed ala spontaneously tends to assume a normal position.

In some cases it is necessary to carry the undermining well over to the other side of the tip to provide room for the new intercrural angle to lie in contact with its fellow and sit correctly over the end of the septum. In this position it is fixed by a mattress-suture passing through the anterior parts of both mesial crura. McIndoe has recently clarified and defined this method.* In severe cases an incision must be made in the middle of the columella separating one mesial crus from the other, and carried forwards into the tip of the nose curving towards the normal side. It is sometimes necessary to prolong the incision backwards, carrying it round the out-turned extremity of the mesial crus and coming out into the vestibule. In all cases the intranasal incision, already described for milder cases, must be made in addition. The mesial crus, having thus been freed, is slid forwards into correct position, and held there by skin sutures in addition to the mattress-suture described. The sliding forward of the half-columella in this manner in unilateral cases is comparable with the sliding forward of the whole columella in bilateral cases. (Fig. 814.) By these steps the intercrural angles are rendered symmetrical and the tip of the nose is made normal in appearance.

To sum up: it is unlikely that all these procedures will be required in any one case but, in order to remove the hare-lip stigma, the surgeon should be prepared to advise a group of them, selected in accordance with the deformity, e.g.:—

Flat contour; depressed tip; wide nostrils.

1. Buccal inlay and provision of special prosthesis.
2. Plastic operation to re-form nose-tip and narrow nostrils.
3. Cupid's bow operation on the lip margin.
4. Cartilage or bone graft to nose bridge.

These may, with good technique, be combined into two operative stages.

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* A. H. McIndoe "Correction of Alar Deformity in Cleft Lip," *Lancet*, Mar. 12, 1938, i, 607.

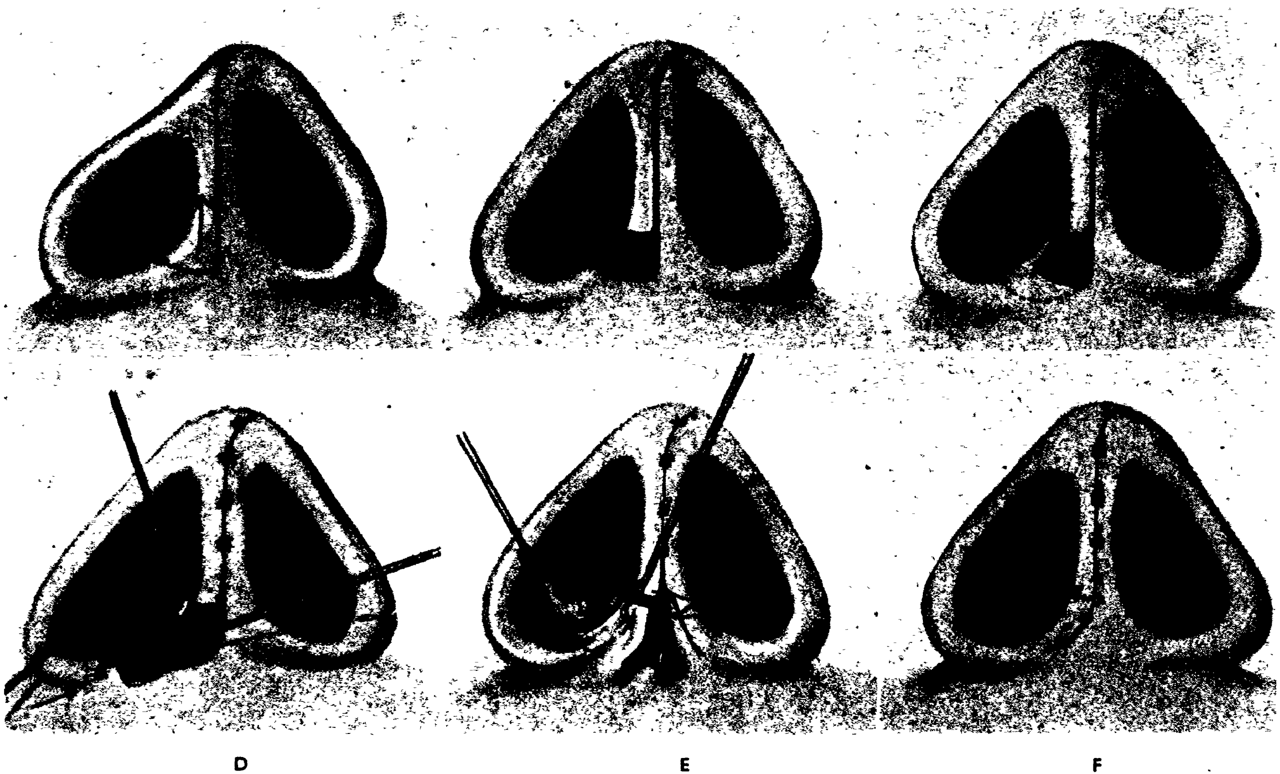

Fig. 814.—Operation for flat ala (severe). A, First incision to advance the half-columella. B, Half-columella advanced. C, Secondary incisions to free alar base and to raise small triangular flap from floor of nostril. D, Flap raised : alar base freed. E, Flap transposed. F, Final suture. Reproduced by permission of *The Lancet*.

Flat ala ; crooked nose ; irregular lip margin and bad lip scar.

1. Osteotomy of nasal bones and straightening of nose.
2. Alar plastic.
3. Muscle re-suture and Cupid's bow operation.

In most cases it is advisable to leave the Cupid's bow operation as a final *pièce de résistance* until after the lip scar has received attention and the muscle layer has been sutured.*

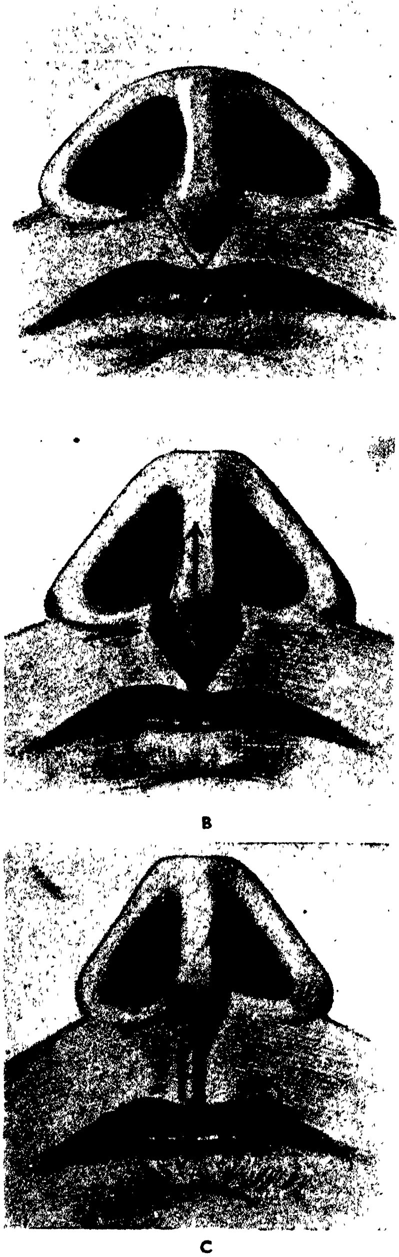

Fig. 815.—A, incision for flat tip (bilateral). B, advancement of tip. C, suture.

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BUCCAL INLAY IN THE RESTORATION OF UNDER-DEVELOPMENT OF THE CHIN

These patients present a deformity that is depressing both to themselves and to their parents. It can be relieved to an amazing extent by the operative technique of the buccal inlay. (Fig. 816.) The details are precisely similar to those already described for the retroposed upper lip in hare-lip deformities. An incision is made in the lower buccal sulcus, from premolar to premolar, and deepened with a knife, not a rugine, until the soft tissues of the chin can be brought well away from the mandible. The whole of this raw surface is now skin-grafted by using a mould held in position by a dental appliance. It is not uncommon for certain parts of the cavity, particularly over the prominence of the bone, to show small areas of necrosis in the skin-graft. These must be treated carefully until the whole has epithelialized. At no time must the cavity be left without the dental mould until the time has arrived when the skin-graft ceases to contract. This may be some two to three months after operation. These skin-grafted cavities appear to stand up well to wear and tear, but occasionally the pressure of the appliance has unduly exposed the neck of a tooth in the early stages of restoration.

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* Previous references to the use of the buccal inlay in hare-lip and cleft-palate surgery are to be found in the following papers:—Gillies, H. D., and Fry, W. Kelsey, "A New Principle in the Surgical Treatment of Congenital Cleft Palate and its Mechanical Counterpart," *Brit. Med. Journ.*, 1921, i, 335. Kilner, T. P., and Jackson, T., "Skin grafting in the Buccal Cavity," *Brit. Journ. Surg.*, 1921, 22, ix, 148. Gillies, H. D., and Kilner, T. P., "Hare-lip Operations for the Correction of Secondary deformities," *Lancet*, Dec. 24, 1932, ii, 1369.

Orthodontic methods of correcting the lower teeth do not appear to have any satisfactory result in producing a prominence of the chin, merely bringing the teeth into line without affecting the bone. A good cosmetic chin can be made by bone-grafting, but this requires an external incision and is not, in my opinion, so accurate in effect as the method described.

This inlay operation is also of value in edentulous cases in which a full lower plate has to be fitted on an inadequate sloping ridge. The inlay is designed with the express purpose of assisting the dental surgeon to obtain a good grip on the mandible for his plate.

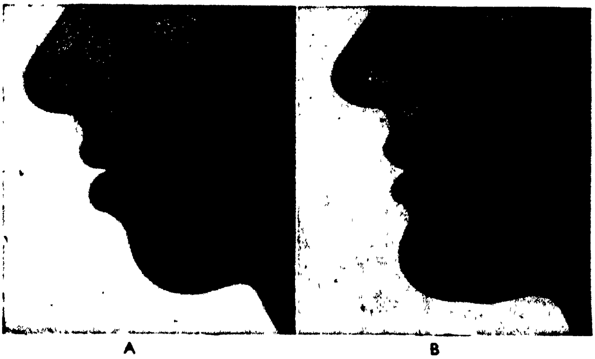

Fig. 816.—A, bird-face deformity. B, result of treatment by buccal inlay and creation into epithelial pouch into which shaped dental prosthesis is placed.

Dental work by Mr. E. A. Hardy, London.

CLEFT PALATE

Such a notable advance in the technique of cleft-palate work has occurred since the first edition of this work that this section has now been entrusted to one of the chief leaders in this subject (Chap. XXXV, Wardill, p. 1607). This satisfactory state of affairs appears to me to follow a volume of work and thought in many countries. A typical palate restoration may now be described as consisting of the Veau closure of the nasal mucosa ; long lateral incisions (Addison) ; fracture of the hamular processes and extensive freeing from the lateral pharyngeal wall ; Wardill's pharyngoplasty and some form of palatine-flap operation ; Veau, the four-flap or VY advancement. Although normal speech can now be expected as the rule rather than the exception, there are cases, especially of the secondary variety, in which there has been loss of tissue or a gross failure to develop, in which the partial repair—the Gillies-Fry operation—is still indicated. Roughly speaking, this consists of separating the soft palate from the hard and freeing each lateral wall until they fall into position with the pharyngeal constrictor. The raw edges and surfaces thus produced must be covered by some form of epithelium, either a flap or free-skin graft. Some quite useless palates from the functional point of view, when they are treated by this method, combined with a Wardill pharyngoplasty, will give a most excellent speech result ; but only in exceptional cases is this operation indicated (Fig. 817).

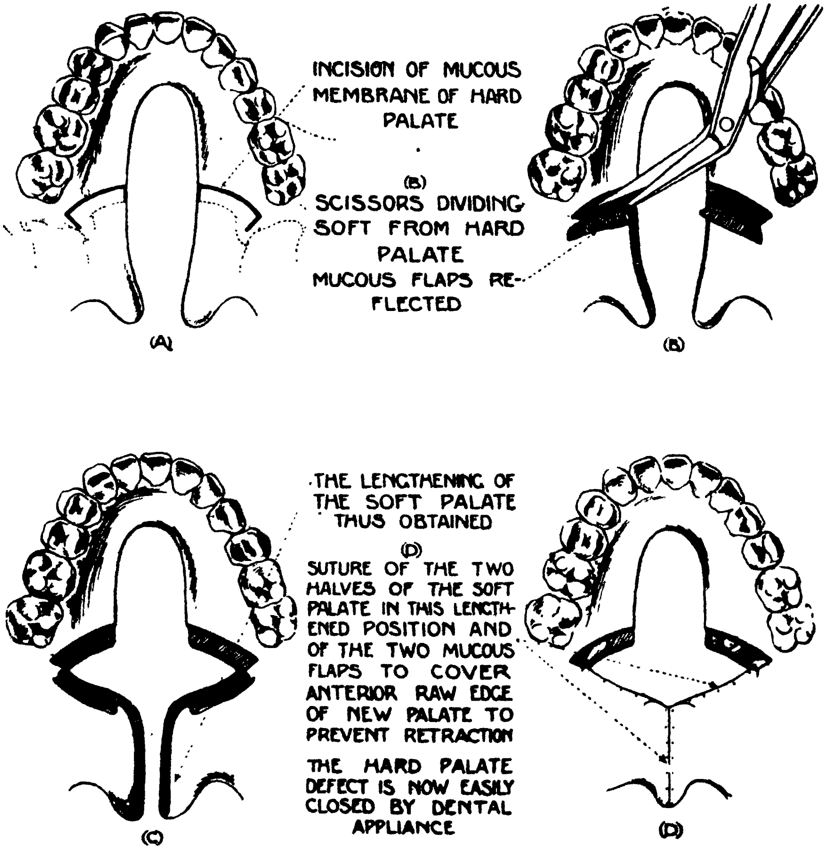
INCISION OF MUCOUS MEMBRANE OF HARD PALATE
(B)
SCISSORS DIVIDING SOFT FROM HARD PALATE
MUCOUS FLAPS REFLECTED
(A)
(B)
THE LENGTHENING OF THE SOFT PALATE THUS OBTAINED
(D)
SUTURE OF THE TWO HALVES OF THE SOFT PALATE IN THIS LENGTHENED POSITION AND OF THE TWO MUCOUS FLAPS TO COVER ANTERIOR RAW EDGE OF NEW PALATE TO PREVENT RETRACTION
THE HARD PALATE DEFECT IS NOW EASILY CLOSED BY DENTAL APPLIANCE
(C)
(D)

Fig. 817.—Diagrams illustrating the Gillies-Fry method of closing cleft of hard palate and of reconstructing efficient soft palate by combined operative and mechanical means.

FRACTURES OF THE FACE

Principles of treatment.—These are the same principles as those that are well established or practised in other regions of the body, namely :—Replacement into normal position at as early a date as possible, and retention of fragments at complete rest in this position. The modifications are due to variations of the local position of each fracture. Thus, any fracture confined to the mandible when teeth are present on both fragments can be replaced and immobilized by fixing the teeth of the lower jaw in occlusion with those in the upper jaw, a task which is naturally allotted to the dental surgeon.

Fractures of the mandible.—Peculiar fractures of the mandible, that of the condyle for instance, are not, in the majority of clinics, treated by replacement, rest for the main fragment being sufficient to restore function. When a fracture passes behind the last tooth of the body of the mandible, an edentulous posterior fragment tends to receive a marked pull forwards and inwards with rotation because of the action of the pterygoid, temporal and masseter muscles. This fragment so displaced presents great difficulty, and there will be considerable loss of function and appearance if it is not adequately corrected. Three operative procedures are recommended.

1. **Inter-osseous wiring.**—If the case is clean when received, an incision may be made close to the angle of the jaw through the platysma and the fracture exposed, reduced and wired with number 25 s.w.g. stainless steel wire. Two wires are better than one, and the lower wire near the border may with advantage be put in in the form of a figure of eight.* The anterior and large fragment of the rest of the mandible can be fixed to the skull by mechanical means through the upper teeth, e.g. inter-maxillary wiring, or cap splint.

2. An operation described by **Ivy and Curtis**†, amongst others, in which, through a small incision, a hole is drilled in a posterior edentulous fragment and a stainless steel wire loop passed through this hole ; the wire is then brought through the wound towards the mastoid. A plaster skull cap carrying an outstanding bar in this region is applied and the wire attached to this post in such a way as to retract the posterior fragment into position. The objections to this method are that only a one-direction pull can be obtained at any given time and a completely firm headcap is not always achieved. If any infection occurs the method is likely to be abandoned.

3. **The Roger Anderson crossed pin method.**—This has been applied with great success. Two crossed pins are passed into each fragment, avoiding any roots of teeth in the anterior portion. The fragments are manually replaced into position, where they are fixed by a crossed bar between the two sets of pins ; this manœuvre is made possible by universal joints of the Walker Clouston type.‡ Further rest can be obtained for the fracture by inter-maxillary wiring of the main fragment for a week or more. In the most successful cases the

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* Stewart Gordon, R.C.A.M.C.; personal communication, 1942.

† Fractures of the Jaws, Philadelphia, 1938.

‡ M. A. Rushton and F. A. Walker, Mandibular Fractures treated by Pin Fixation, *Amer. Jour. Orthop. & Oral Surgery*, 1942, xxviii, 307.

reposition is anatomical and perfect, and can be retained without any complication for many weeks.

Fractures of the upper jaw.—These have been classified by Ivy and Curtis.* From an operative point of view they can be divided into those which involve a displacement of the upper teeth and those which do not. Where the upper teeth are displaced, the displacement may be upward and/or backward, or the whole tooth-bearing area may be floating, including the palate. It can usually be manipulated into good occlusion by the application of dental splints when a sufficiently strong fibrous union eventually maintains accurate reposition. When there is serious impaction of the displaced tooth-bearing area of the maxilla this should be rigidly disimpacted so that the dental surgeon's appliances can work efficiently. If slow traction is likely to produce the desired forward movement of the maxilla, it may be provided by a variety of applied forces described in works on jaw fractures.† When the fracture of the upper jaw is confined to or includes the middle third of the face, a particular facies called "dish-face" is produced. In these cases an operation is essential to disimpact the malar bone and the nasal arch from the posterior part of the maxillæ and ethmoids. One of the methods described under fractures of the malar should be employed, while the nose should be restored as far as possible by complete disimpaction with Walsham's forceps and Ash's nasal septum forceps, and the arch be manipulated into normal position.

Fractures of the malar.—Signs and symptoms of this fracture are :—

1. Alteration in contour, immediate swelling followed by flattening.
2. Anæsthesia over the distribution of the infra-orbital nerve.
3. Unilateral epistaxis from hæmorrhage into the antrum.
4. Trismus, combined with a deviation of the mandible to the opposite side, due to pressure of a displaced malar zygomatic fracture on the tip of the coronoid and temporal muscle.
5. Diplopia, due to displacement downward of the orbital plane. The globe of the eye may be displaced downward and backward (enophthalmos) or there may be proptosis due to the encroachment of the malar element into the orbital cavity.

Its replacement may be undertaken by one of the three following methods :—

(*a*) **The temporal route.**—An inch-long incision exposes the temporal fascia clothing the temporal muscle. If a lever of the Bristow elevator type is passed down this fascial plane towards the mouth it can be hitched behind and below the tuberosity of the displaced malar and, by different leverages, achieve disimpaction and replacement. No retention is required, and the results are most satisfactory. This method is applicable mostly to the simpler type of depressed fracture without comminution.

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* Fractures of the Jaws, Philadelphia, 1938.

† Fry, Shepherd, McLeod and Parfitt, The Dental Treatment of Maxillo-Facial Fractures, Oxford, 1942.

(*b*) **The antral route.**—Direct replacement after disimpaction can be readily performed and the floor of the orbit and malar position maintained by direct packing (gauze and Whitehead's varnish). The surgeon may have to wire the frontal process of the malar to the frontal bone and the broken halves of the orbital plate. There is a small percentage of late and mild post-operative antral infection.

(*c*) **Skeletal traction.**—This may be applied to the malar by driving two crossed pins into it, or threading a loop of wire through it and attaching these to a skull cap or bar fitted with a universal joint. Old depressed fractures not easily disimpacted are best treated by camouflage operations.* The malar prominence can be restored by inserting bone chips† or by a block from the ilium. A small flat plate slipped along the floor of the orbit will raise the eye level, much improve the diplopia, and cure the enophthalmos. An outstanding case of diplopia of 2½ years' history was completely cured by this method.

COSMETIC REDUCTION OPERATIONS

Speaking generally, it is easier to reduce than to add and, when indicated, reduction operations are usually satisfactory to the patient. Under this heading are included the reduction of the nasal bridge in humped-nose ; of various deformities of the tip of the nose ; of excess skin of the face and neck, such as wrinkles and double chin ; of hypertrophied mammæ ; and of excessive deposits of superficial fat and skin on the abdomen.

The nose.—Reduction of the bridge is carried out through bilateral intra-vestibular incisions which are continued forward to the tip and then backward into the membranous portion of the septum. By this fan-shaped incision the bony and cartilaginous framework of the nose is easily exposed on its superficial aspect without in any way incising the external skin. The bony hump can be sawn and chiselled, and the cartilage cut with a knife, in such a way as to reduce the bridge and shorten the length of the nose from above downwards. In addition, through this same incision any excess or undue prominence of the alar cartilages can be removed. Care must be taken to leave a sufficient rim of alar cartilage to preserve the alar margin, otherwise an unpleasing effect is likely, due to inward collapse of the nostrils. In reducing the lining and cartilaginous framework, care must be taken to excise a strip parallel with the septum, or any excess of the upper lateral cartilages (the triangular expansion of the septum). Otherwise an unpleasant broad effect is left just above the tip. The exact reduction of the alar cartilages must vary with the individual case. When a nose has been thus reduced the base of the nose is frequently too broad for its new height ; in these cases osteotomy with infracture of the frontal processes of the maxillæ is indicated. Filing is of more doubtful value. Also, when a very large and long nose has been shortened and reduced, the alæ will be found too big for the new position of the tip and will spread laterally. Such a spread can most satisfactorily be dealt with by a wedge excision of the base of the alæ keeping the scar on the cheek-nose junction-line. On re-suture of the membranous part of the septum, the position of the tip can to a certain extent be controlled by the manner in which the catgut stitches are inserted ; thus, if a tip-tilted effect is required, the columella is sutured far forward on the septum, and if the tip is to be placed backwards the reverse tactics are applied. (Fig. 818.)

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* A. H. McIndoe, Treatment of old Traumatic Bony Lesions of the Face, *Surg. Gyn. Obst.*, 1937, lxiv, 376.
† Rainsford Mowlem, personal communication, 1942.

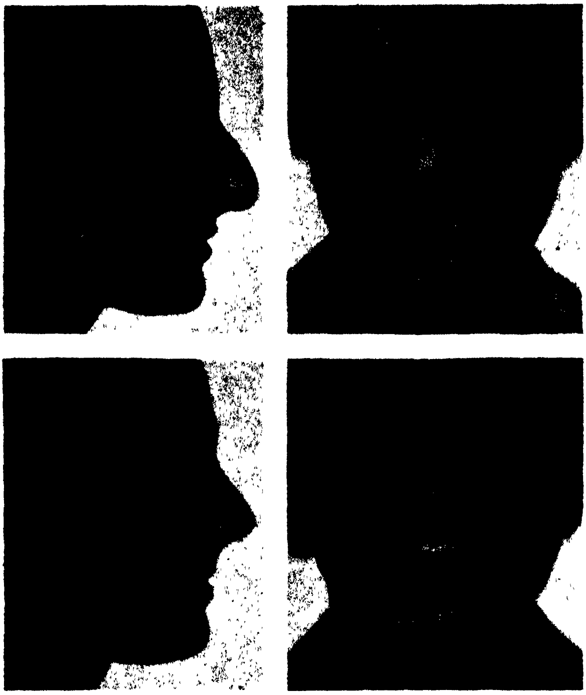


Fig. 818.—Overgrowth of bony cartilaginous framework of nose. Reduction and shortening through intranasal incisions.

The instruments required for these intranasal manipulations are: nasal speculum, retractors, fine hooks, dissecting scissors, Howarth's elevator, nasal saw and chisels.

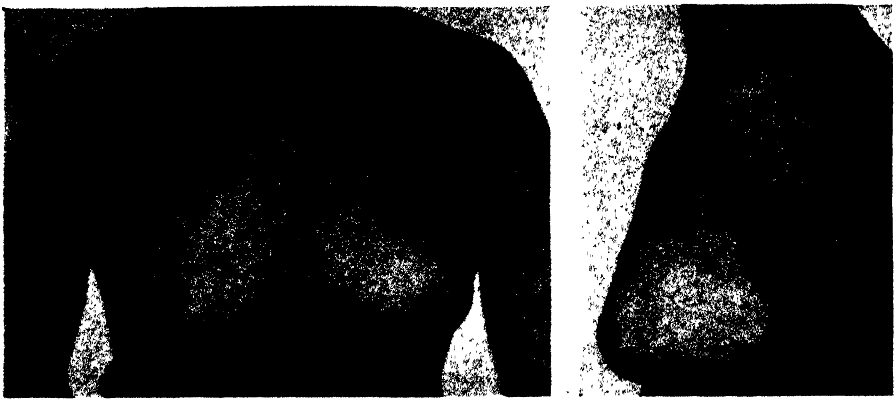
Nasal reduction is also required in the well-known condition of rhinophyma or sebaceous adenomatous hypertrophy. Three methods are available : (*a*) simple shaving with a razor until a normal contour is obtained, leaving epithelialization to take place from tiny islands of skin ; (*b*) replacement of the whole skin of the nose by flap or skin-graft; and (*c*) dissection of the adenoma from between raised flaps of skin and underlying cartilage. Each of these methods has given satisfactory results, the choice being decided by the individual case.

Excess skin of the face and neck. **Eye-lids.**—Folds and bags are not only unsightly, but those on the upper lid frequently weigh heavily upon the levator muscle, often causing the patient to complain of a sensation of weight and fatigue and even chronic headache. The folds are picked up with forceps and the amount to be removed by scissors then judged. The subcuticular suture used to draw the edges of the gap together is planned to lie, in the upper lid, in the natural fold above the tarsal plate, and in the lower as near the lid edge as is practicable. At the outer canthus in the lower lid it is usually necessary to curve the incision slightly downward as well as outward beyond the canthus for a short distance. Great care must be taken in the elderly, when the muscles are atonic, to avoid producing an ectropion of the lower lid.

Forehead furrows and lines in the face are removed by excision of wedges of skin in the pre-auricular and temporal regions, and those below the chin by a similar removal in the post-auricular mastoid hair-line. These two incisions are in some cases made to meet round the lobule of the ear. As much undermining of the skin of the face and neck is carried out as is required to obliterate the unsightly lines without producing a mask-like appearance of the whole face or undue obliquity of the eyes. In certain cases it will be necessary to undermine the skin of the face as far as the malar region, where the attachment is occasionally firm. In general, where a permanent effect is required, more extensive undermining is indicated. It is not surprising therefore that hæmatoma formation is one of the chief bugbears in this cosmetic procedure and must be dealt with promptly. Excessive fat beneath the chin should be removed through the same type of bilateral post-auricular incisions, so that the scars are subsequently invisible. If this cannot be done, fat in this area should, in my opinion, be left alone. Horizontal incisions beneath the chin are not satisfactory in that the scars, however good they may be, are usually noticeable, while a vertical scar tends to end in a disastrous cheloid.

Reduction of the breasts.—Virginal hypertrophy of the breasts is considerably more common than is recognized. In a few, the condition is attended by no physical or psychic complaint, but in the majority there is very considerable embarrassment from the weight and prominence of the mammæ. The pull on the chest-wall bows the head down and the mammary bulk interferes with the free movements which many women wish to use in sport. On the psychic side the distress is very often marked, and the patient contrives many methods of hiding the breasts, and many tricks to prevent their size being discovered. Owing to the fact that the medical profession, as well as the laity, do not realize that reduction can be satisfactorily carried

A



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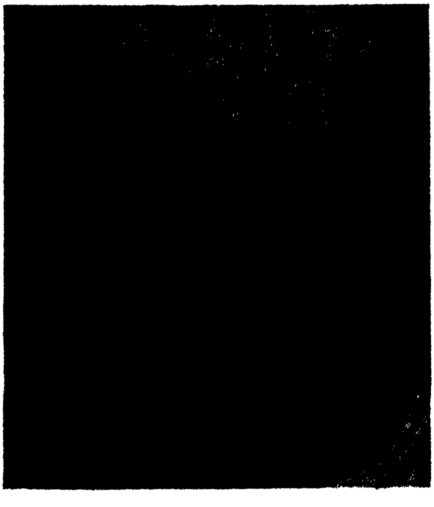
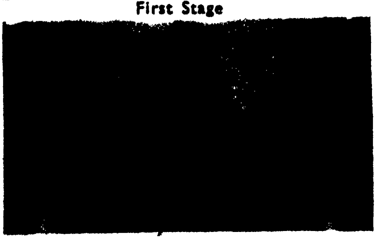


First Stage



Second Stage

out without unsexing the patient, as in the wholly objectionable operation of complete bilateral amputation, the condition is often borne without hope of improvement.

Two operations are recommended, in both of which the nipple is preserved and re-implanted at a higher level in order not only to maintain certain of its functions, but to make the result of æsthetic value. A large quantity of breast tissue, fat and skin is removed. The removal of the breast tissue is made justifiable by the fact that the gland is abnormal and that mammary feeding is carried out only with difficulty even if the patient is not operated upon. Up to 4 to 15 lb. weight has been removed from two breasts. Self-explanatory diagrams and photographs of the two operations recommended are given in Figs. 819 and 820. When it is specially desired that the incision be kept from extending outwards towards the axilla, and where a conical type breast is aimed at, a wedge of skin and breast tissue removed from beneath the nipple in its new position will be found satisfactory. Its disadvantage lies in the vertical scar which runs down from the nipple over the surface of the breast ; this scar is found in practice to be a very excellent one, if due precaution is taken to relieve it from tension by deep catgut sutures. There is a temptation to pull the skin-edges tightly together underneath the breast to get a good shape ; but the modelling of the breast tissue depends on the fixation by catgut sutures of the mammary tissue itself, and the suture of the new mamma to the pectoral fascia. The skin can then be excised in the form of a wedge below the nipple to give a smooth covering without tension and to form a mild support. In separating the skin from the breast tissue proper the practice of dry-swab dissection has everything in its favour. It reduces the bleeding to a minimum and eliminates a great deal of the shock that might occur in such an extensive operation.

The abdomen.—Removal of large quantities of skin and fat from the abdominal wall may be done satisfactorily by either a transverse, vertical or combined transverse-vertical incision. A vertical ellipse including the umbilicus has the advantage of reducing the size of the hips.

CHRONIC RADIO-DERMATITIS AND RADIO-NECROSIS

The widespread use of radium and X-rays as therapeutic agents, and their well-recognized potency for evil as well as for good, has not unnaturally resulted in a considerable number of cases of chronic dermatitis. While many of the milder degrees of burn heal, at least for a time, under medical treatment, chronic ulcerative radio-dermatitis, once established, admits of one form of treatment only. Complete excision is followed by rapid relief of symptoms and freedom from risk of carcinomatous change. Cure, however, cannot be considered as satisfactorily attained if no attempt is made to avoid the secondary contraction which follows healing by granulation. Thus

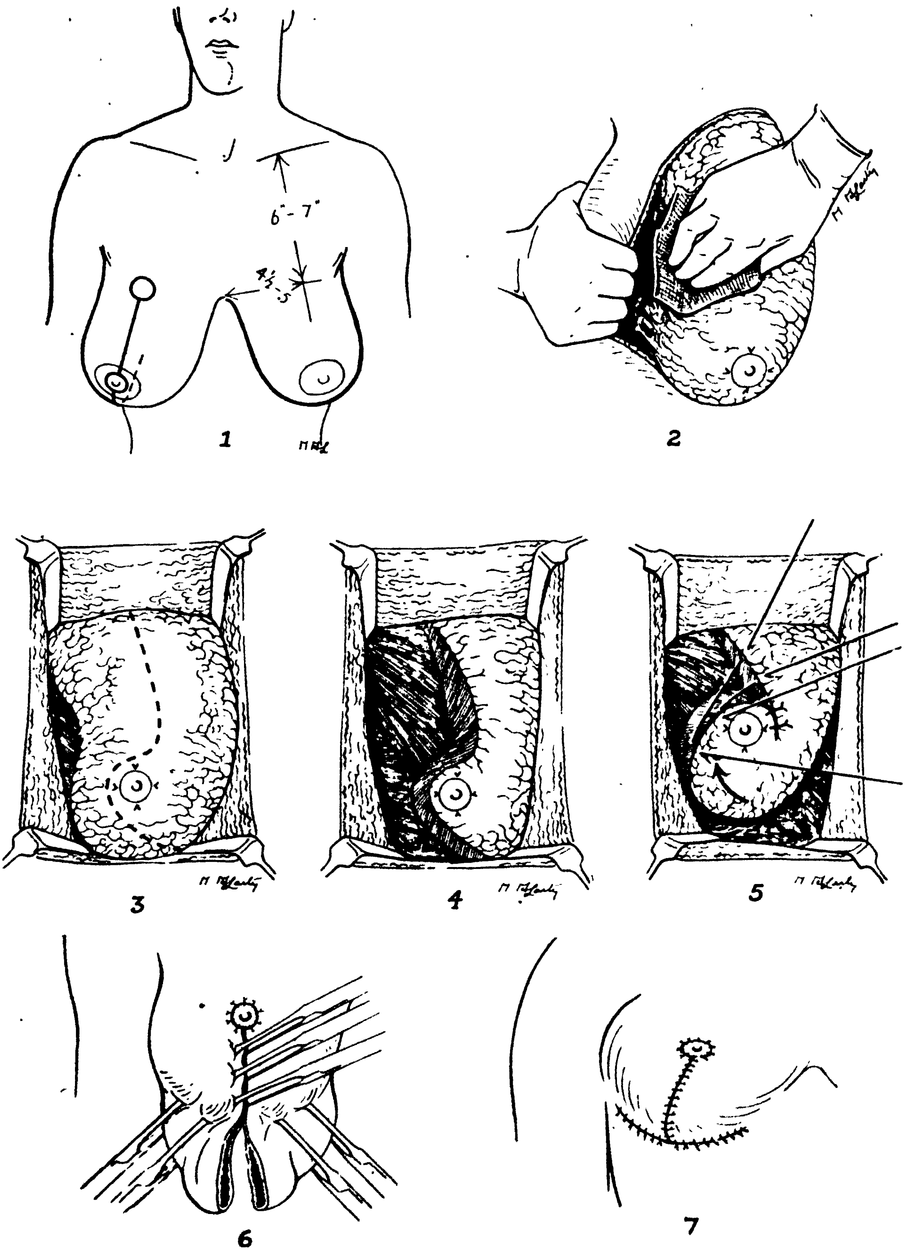


Fig. 820.—Operation for reduction of the breasts.

1. Mammary hypertrophy. Normal measurements for first incisions.
2. Swab dissection of breast tissue from skin and muscles, preserving the inner blood supply.
3. Incision to remove outer half of breast delineated.
4. Inner half of breast tissue with nipple preserved on internal mammary vessels.
5. Rotation upwards and outwards to form circular breast. Catgut stitches.
6. Nipple sutured. Excess of skin picked up with Allis' forceps.
7. Skin suture.

Surgeons should note that Fig. 820 illustrates an external pedicle carrying the nipple. The common operation has an internal pedicle of exactly similar character.

the problem of the immediate replacement of the excised tissue with healthy skin brings the condition within the purview of the plastic surgeon.

These patients fall naturally into three groups :—

(*a*) Patients who have received a single dose of X-rays or radium for diagnosis or treatment.

(*b*) Patients who have undergone treatment for a chronic condition, and who received small but oft-repeated doses for a long period, often resulting in ulceration.

(*c*) Professional X-ray workers suffering from burns of the hands and face.

In the acute stages the lesion consists of a central slough where the more intense rays have produced massive cell death, surrounded by an extensive zone of inflamed skin in which the less powerful rays have produced profound circulatory and functional changes without actually killing the cells *en masse*. During this period the inflammatory reaction is so widespread that no line of demarcation between healthy and devitalized tissues can be defined. For this reason, too early excision and grafting is hazardous and may give poor results. The more commonly encountered chronic form of the disease either follows acute necrosis or is chronic from the outset. In the latter type of burn the sequence of events is distinguished by an insidious change in the character and functions of the skin, and by an equally slow depression of its vitality, culminating in intractable ulceration.

From a surgical point of view, the distinguishing feature of chronic radio-dermatitis is that the whole area can be dissected up from the subjacent tissues with ease, there being a well-marked cleavage plane between normal and devitalized structures. Beneath the ulcer it may be necessary to resect fasciæ, tendons, muscles or bone in order to reach healthy tissue. These are frequently found normal in form but converted into a tough white immobile mass of fibrous tissue. The full effect of excessive radiation may not become apparent at once, and a latent period of months or years may intervene between the last dose of X-rays and the final breakdown of the tissues. Pathologically it is then identical with the chronic stages of radio-necrosis.

The indications for operation are :—

1. *Pain, itching, ulceration, and discharge.*—As a rule, with frank ulceration the patient complains of exquisite pain, constant day and night, and producing a condition of mind and body miserable in the extreme. In the telangiectatic and rind-like areas an intolerable itching may drive the patient to despair. The relief of pain and irritation and the mental improvement which usually follow immediately when the area is excised are most striking.

2. *Deformity from contraction.*—As a rule, this is much less marked than with burns by fire or scalds, owing to the complete absence of cheloid and the smaller amount of fibrous tissue formed. It is most frequently met with in patients who have undergone extensive treatment for diseases, such as lupus, which, by themselves, produce

contraction. It is rather a feature of the condition treated than of the treatment. In the neck, a certain amount of retraction of the chin and eversion of the lower lip may take place. Contraction deformities also occur in the neighbourhood of the eyes and nose.

3. *Cosmetic appearance.*—The unpleasant and disfiguring appearance of the skin, especially on exposed parts, in the milder degrees of burn unaccompanied by ulceration can frequently be greatly improved by grafting.

4. *Epitheliomatous change.*—Cancer supervenes so often upon long-standing ulcerative radio-dermatitis, especially after repeated doses, such as occur on the hands of X-ray workers, that the possibility of its presence can never be excluded by superficial inspection. Microscopical examination of the excised area should therefore never be omitted.

Treatment.—Although this falls naturally into the two stages of (*a*) excision and (*b*) repair, it is important to emphasize the point that in the vast majority of cases both stages are carried out at one operation. Only in an acute or badly-infected ulcer, or in one where a healthy base is not obtained after primary excision, is it advisable to divide the operation into two stages and to allow the base to granulate before grafting. In such instances the diathermy knife is much favoured as an instrument for excision.

Excision is usually simple and should extend into healthy skin on all sides. A guide to the depth of excision is furnished by traction on the rind-like superficial tissues, thereby establishing a cleavage-plane which is easily followed. Where the ulcer involves deeper structures, such as muscle or bone, these should be freely excised and any sequestra removed. An attempt is thus made to reach healthy tissue in all directions, but it is sometimes wise to leave deep scar in important organs, and trust to the good effect of a healthy skin-flap. It is rarely difficult to decide the limits of excision, but where epitheliomatous change is suspected, the operation should be performed by the diathermy knife and microscopical examination of the edges and base of the excised area carried out. In these cases every effort must be directed to thorough removal of all the diseased tissues without thought to the problem of subsequent repair. The use of the diathermy knife does not prohibit the immediate application of grafts. In our experience a satisfactory " take " has always resulted.

The method of repair depends on the quantity of tissue lost, the age and sex of the patient, the position of the burn, the cosmetic result desired, and the mechanical problem of transplanting the graft to its new position. Three methods are available :

(*a*) Thick razor grafts.
(*b*) Full-thickness dissected grafts.
(*c*) Direct flaps and tubed pedicles.

(*a*) **Thick razor grafts.**—These, applied on a Stent pressure-mould of the defect, have a wide field of use, and the method is the simplest and most certain available for covering a raw area. Although the immediate result is sometimes disappointing, in that the graft may be wrinkled, hard and depressed, it later becomes soft, smooth and filled out, and the result compares very favourably with those of other methods. Thick razor grafts are used as a routine on the hands and fingers of X-ray workers ; on the scalp and back where large areas must be covered ; and on the eyelids for the relief of cicatricial ectropion. On the front of the neck the method is advisable where a quick result rather than cosmetic excellence is aimed at. It is not so applicable where a thick covering is desirable, for weight-bearing or where pressure is to be exerted on the surface of the graft. (Fig. 821.)

(*b*) **Full-thickness dissected grafts.**—These are not quite so reliable as thick razor grafts, bus undoubtedly give good results when the take is 100 per cent.

(*c*) **Pedicle flaps.**—These may be of the sliding, rotation, transposed, or tubed pedicle variety, according to the difficulties to be overcome and the cosmetic result desirable. They are particularly applicable where appearance is important, where much tissue has been lost, and where a mobile covering is required for exposed structures. Their chief field of usefulness will be found in extensive burns on the cheek, neck and limbs, and particularly where joints are involved. They are in fact useful in almost any situation except on the hands and fingers. On the scalp, small areas may frequently be obliterated by rotation flaps of neighbouring healthy scalp with or without thick razor grafting of any remaining bare area, so arranged that the hair can conveniently conceal the deficiency. Thus, in both sexes, it is advisable to transpose a bare area from an anterior to a more posterior position so that it can be more easily hidden. More complete loss of the scalp should be covered by thick razor grafts, and a toupée should be worn.

Facial lesions involve so many problems already discussed that no good purpose would be served by dealing with the matter here. On the neck, according to the age and sex, the thick razor graft or a pedicle graft is usually employed. In children and in many women the former is satisfactory, while in men a tubed pedicle of the acromio-pectoral variety gives the best results. In women in whom it is desirable to leave the chest unmarked, and where time is not a great object, a flap raised from the abdomen transferred to the wrist, and finally applied to the neck will solve the difficulty. (Fig. 786, p. 1648.) On the abdomen and buttocks sufficient tissue is usually available in the neighbourhood to make sliding or rotation flaps and, provided all tension is avoided, these unite by first intention. The same may be said of small areas on the back, but as a rule these are best treated by thick razor grafts.

In the axillæ of women, anterior and posterior sliding flaps partly fashioned from any excessive skin covering the breasts will give a good cosmetic result, although thick razor grafts applied on Stent moulds

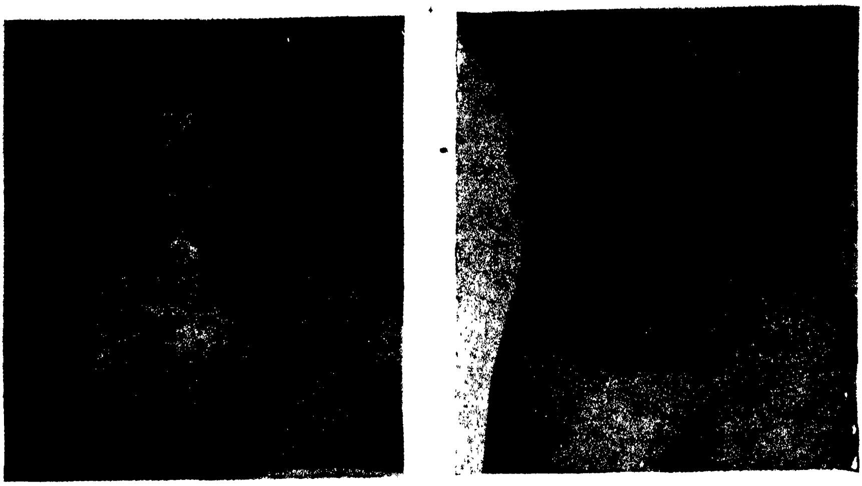


Fig. 821A.—Chronic ulcerative radio-necrosis ; repair by thick razor grafts.

Fig 821B.—Ulcerative radio-necrosis of the neck following treatment for exophthalmic goitre. Right, repair by abdominal tubed pedicle flap.

Fig. 821C.—Bilateral radio-necrosis of elbow regions treated by excision and

are also useful. Around the elbow-joint and on the forearm, flaps may be raised from the side of the chest or abdomen and fitted to the defect according to the technique described later. On the hands and fingers, a particularly common site for burns, thick razor-grafting after careful excision is by far the most satisfactory method ; because of their thick unwieldy nature full-thickness flaps should rarely be employed. Particular attention should be paid to the webs of the fingers, if these are involved, in order to prevent any subsequent limitation of movement. Thick razor grafts or direct transposed flaps from the opposite limb are to be preferred foi the lower limbs. The latter are almost essential in the region of the ankle-joint, where pressure movement and weight-bearing are important.

Results.—It has been already noted that radio-dermatitis and necrosis are cured as soon as excision is completed. The relief of the pain is usually immediate and permanent, even though nothing further is done and the area is left to granulate. The surgical result of healing by granulation is, however, usually deplorable, owing to the contraction deformities which are certain to follow. Success depends entirely on the technical excellence of the plastic treatment.

In general it might be said that the results are most favourable with thick razor grafts and flaps, and that a successful repair in this type of burn may be more confidently predicted than after burns by fire.*

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* Gillies and McIndoe, "Plastic Surgery in Chronic Radio-dermatitis and Radio-necrosis," *Brit. Journ. Radiol.*, New Series, No. 63, Mar., 1933, vi, 132.

CHAPTER XXXVII

OPERATIONS ON THE NECK

By W. E. TANNER

SURGICAL ANATOMY

The cervical lymph system.—The lymphatic vessels and nodes in the neck are arranged in two main groups (Fig. 822) :—

1. A **horizontal system** at the junction of the head and neck which drains into two vertical systems of deep cervical nodes lying on the course of the internal jugular veins. The horizontal chain contains the following groups :—

i. The *submental or suprahyoid nodes* lie superficial to the mylo-hyoid muscles and receive afferent lymphatics from the skin of the lower lip and chin, from the mucous membrane of the front part of the floor of the mouth, and the tip of the tongue. Their efferents drain into the anterior nodes in the upper part of the deep cervical chain.

ii. The *submaxillary nodes* in the digastric triangle lie superficial to, deep to, and in the folds of the submaxillary salivary gland. The posterior nodes become continuous with the upper deep cervical nodes, and lie in contact with the facial artery and anterior division of the temporo-maxillary vein. Their afferent lymphatics drain the front part of the face, the inner side of the orbit, the mucous membrane of the mouth, the teeth and gums, and the anterior part of the tongue. Their efferents pass into the anterior nodes of the upper deep cervical chain.

iii. The *parotid or pre-auricular nodes* lie on the surface of and immediately beneath the parotid fascia, and embedded in the folds of the parotid salivary gland. The lowest members of this group are in contact with the temporo-maxillary vein and the commencement of the external jugular vein ; the external carotid artery lies more deeply. Their afferents drain the external and middle ear, the anterior part of the scalp, the temporal region and eyelids.

iv. The *mastoid or postauricular nodes* lie on the mastoid process behind the ear.

v. The *occipital nodes* lie on the upper part of the complexus muscle.

vi. The *superficial cervical nodes* lie along the upper part of the external jugular and postero-external jugular veins, between the sterno-mastoid and trapezius muscles. These three groups of nodes receive afferent lymphatics from the posterior part of the scalp, the external ear and skin of the neck. Their efferents pass to the deep cervical nodes. The superficial cervical nodes are often enlarged by a retrograde infection spreading backwards from the tonsillar lymphatic nodes.

2. The **vertical systems** of deep cervical nodes, lying along the course

of the internal jugular veins, receive afferent lymphatics from the tonsils, nasopharynx, pharynx, larynx, œsophagus and trachea ; the efferents, from the horizontal chain of nodes and lymphatic vessels which pass directly to them from areas also drained by the horizontal nodes. Anatomically, the deep cervical system consists of two chains, one *antero-external* and the other *postero-external* to the internal jugular vein. These two chains are subdivided into four groups by the anterior belly of the omo-hyoid muscle. This subdivision is convenient on clinical and pathological grounds, because each of the four groups receives afferents from certain parts of the periphery, but as each group is joined by intervening lymphatics, the primary focus of disease is eventually masked by infection spreading from one group to the others.

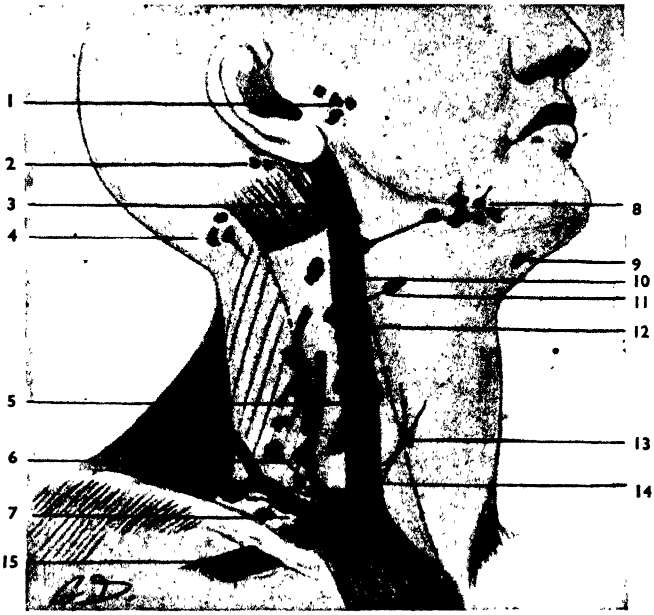

Fig. 822.—Horizontal and vertical systems of cervical lymphatic nodes. The part of the sterno-mastoid muscle reflected downwards is shown in outline.

1, Parotid or pre-auricular nodes ; 2, mastoid or postauricular nodes ; 3, postero-superior nodes of vertical chain ; 4, occipital nodes ; 5, 13, 14, antero-inferior nodes of vertical chain ; 6, 7, postero-external nodes of vertical chain ; 8, submaxillary nodes ; 9, submental or suprahyoid nodes ; 10, 11, 12, antero-superior nodes of vertical chain ; 15, infraclavicular nodes.

The two upper groups lie above the anterior belly of the omo-hyoid, the *antero-superior* lying in front of and external to the internal jugular vein, the *postero-superior* lying behind the internal jugular vein.

The two lower groups lie below the anterior belly of the omo-hyoid muscle, surrounding the terminal parts of the internal jugular, external jugular, subclavian, transversalis colli and suprascapular veins, and becoming continuous with the axillary and mediastinal lymphatic nodes. The *antero-inferior* are continuous with the antero-superior chain, and lie on the internal jugular and the termination of the subclavian veins. The *postero-inferior* are continuous with the postero-superior chain and lie behind the internal jugular vein on the brachial plexus in intimate relation with the transversalis colli, supra-scapular, and external jugular veins, and the outer part of the subclavian vein.

i. The ANTERO-SUPERIOR chain receives afferents from the sub-mental, submaxillary and parotid lymph nodes, and also vessels which pass to them directly from the buccal cavity, the tongue, palate, jaws and teeth, the tonsils, the oro- and naso-pharynx. This group is the one most commonly first affected by the direct spread of tuberculosis along the lymphatics from the mucous surface of the naso-pharynx.

The *tonsillar* lymph node lies on the common facial vein at its junction with the internal jugular, and receives lymphatics direct from the tonsil. When enlarged, this node is felt just below and behind the angle of the jaw under the anterior border of the sterno-mastoid.

The *principal lymph node of the tongue* lies on the internal jugular vein opposite the bifurcation of the common carotid artery. The transmitted pulsation of the vessel can be seen and felt over the node when it is enlarged. A swelling projecting from under the anterior border of the upper part of the sterno-mastoid muscle is a further indication that the antero-superior group is enlarged. The mass may be adherent to the superficial layer of the deep cervical fascia. The deeper nodes may be adherent to the common facial and internal jugular veins.

ii. The POSTERO-SUPERIOR chain lies under the posterior part of the sterno-mastoid muscle behind the internal jugular vein. These nodes receive afferents from the retropharyngeal, parotid, posterior auricular, occipital and superficial cervical lymph nodes, and also from vessels which pass directly to them from the mucous membrane of the naso-pharynx, the pharyngeal tonsil, Eustachian tube, middle ear, and nasal fossæ. Lymphatics from the *pharyngeal tonsil* pass directly to a group of nodes lying deep to the sterno-mastoid just below the tip of the mastoid process on the rectus capitis lateralis muscle. The spinal accessory lies in intimate relation with these nodes just after it has crossed superficial or deep to the internal jugular vein.

When enlarged, the postero-superior group projects from under the sterno-mastoid into the posterior triangle and is traversed by the spinal accessory nerve and branches of the cervical plexus of nerves.

iii. The ANTERO-INFERIOR chain lies on the outer side of the internal jugular vein, on the scalenus anticus muscle, in intimate relation with the phrenic nerve and the thoracic or right lymphatic duct. These nodes receive afferents from the antero-superior group of nodes and vessels, which pass directly to them from the larynx, trachea, œsophagus, and thyroid. Their efferents communicate with the superior mediastinal nodes.

Tuberculous disease commonly spreads to these nodes from the upper cervical groups, but they become enlarged before the upper nodes when the disease is secondary to mediastinal or mesenteric infection.

iv. The POSTERO-INFERIOR chain lies behind the internal jugular vein on the levator anguli scapulæ, scalenus medius, and upper part of the serratus magnus muscles, in intimate relation with the lower branches of the cervical plexus and the brachial plexus. Afferent vessels pass to this group from the postero-superior chain and from the axillary nodes. Their efferents communicate with the inferior group of cervical nodes and the mediastinal nodes.

The **retropharyngeal nodes** lie behind the upper part of the pharynx in front of the prevertebral fascia and rectus capitis anticus major muscles. They receive afferents from the nasal fossæ, naso-pharynx, and Eustachian tubes ; their efferents pass to the upper deep cervical nodes. When suppurating, they form a swelling on either side of the middle line as seen from the mouth ; the postpharyngeal abscess resulting from caries of the cervical spine is usually median in position and behind the prevertebral fascia. In either case an abscess may be of such a size that it extends into the neck and presents at the posterior border of the upper part of the sterno-mastoid.

The **suprasternal nodes** lie in Burns's space just above the manubrium sterni.

The lymphatics of the head, face and neck.—**The scalp.**—The lymphatic vessels from the frontal region end in the *parotid* nodes ; from the temporo-parietal region, in the *parotid and posterior auricular* nodes ; from the occipital region, in the *occipital, superficial cervical and deep cervical* nodes.

The ear and external auditory meatus.—Vessels from the outer surface of the ear and anterior wall of the external auditory meatus pass to the *parotid* nodes ; from the margin and upper part of the inner surface of the pinna, the inner surface and posterior wall of the meatus, to the *posterior auricular and upper deep cervical* nodes ; from the floor of the meatus and lobule of the pinna, to the *superficial cervical and upper deep cervical* nodes.

The face.—The lymphatics from the eyelids and conjunctivæ end in the *parotid* and *submaxillary* nodes ; from the posterior part of the cheek, in the *parotid* nodes ; from the anterior part of the cheek, the side of the nose, the upper lip and the lateral third of the lower lip, in the *submaxillary* nodes.

Vessels from the temporal and zygomatic fossæ pass to the *internal maxillary* and *upper deep cervical* nodes ; the deeper vessels of the cheek and lips, to the *submaxillary* nodes. The superficial and deep vessels of the middle third of the lower lip pass to the *submental and submaxillary* nodes on both sides of the neck.

The nasal fossæ.—The lymphatics from the anterior third of the nasal fossæ are continuous with the vessels in the skin of the nose, and end in the *submaxillary* nodes ; those from the posterior two-thirds of the nasal fossæ and the air-sinuses pass to the *retropharyngeal* and *upper deep cervical* nodes.

The mouth.—The vessels from the gums end in the *submaxillary* nodes ; those from the hard palate and soft palate pierce the superior constrictor and end in the *retropharyngeal, subparotid* and *upper deep cervical* nodes.

The vessels from the front part of the floor of the mouth pass to the *submental* nodes and directly to the *upper deep cervical* nodes and *supra-omo-hyoid* node ; from the rest of the floor of the mouth the vessels terminate in the *submaxillary, upper deep cervical* and *supra-omo-hyoid* nodes.

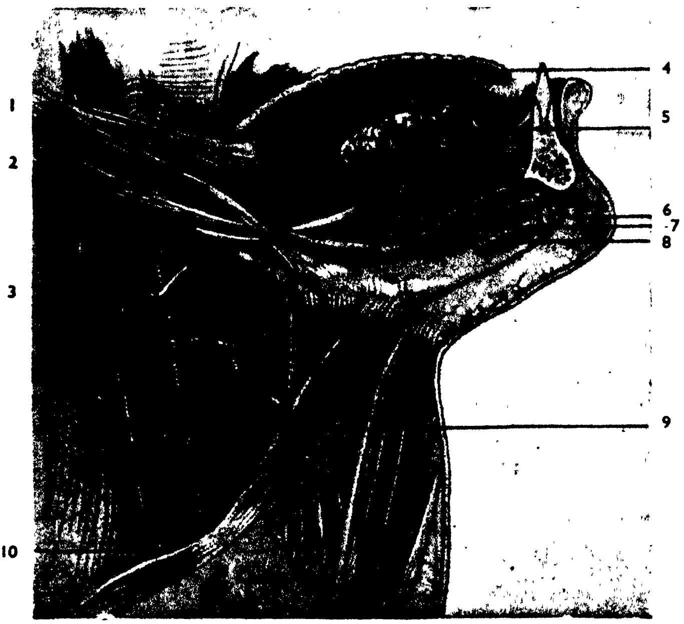

Fig. 823.—Lymphatics of tongue.

(After Poirier.)

1, Stylo-hyoid ; 2, digastric ; 3, upper nodes of deep cervical chain (jugulo-digastric) ; 4, lymphatic plexus in tongue ; 5, sublingual gland ; 6, submental gland ; 7, submaxillary lymph nodes ; 8, mylo-hyoid muscle ; 9, carotid artery ; 10, jugulo-omo-hyoid lymph node.

The tonsil.—The lymphatics from the *tonsil* end in the *upper deep cervical* nodes.

The tongue.—The lymphatics of the tongue have a wide distribution, and may be divided into those in front of the circumvallate papillæ (buccal portion or anterior two-thirds of the tongue) and those from the pharyngeal portion (posterior third of the tongue). (Fig. 823.)

The vessels from the outer third of the dorsal surface, the lateral border and under-surface of the buccal portion drain into the *sub-*

maxillary nodes, the *jugulo-digastric* and *supra-omo-hyoid* nodes. (Fig. 824.)

The vessels from the middle third of the dorsum, the tip and undersurface in the region of the frænum, drain into the *submental, submaxillary, jugulo-digastric* and *supra-omo-hyoid* nodes on the *same side,*

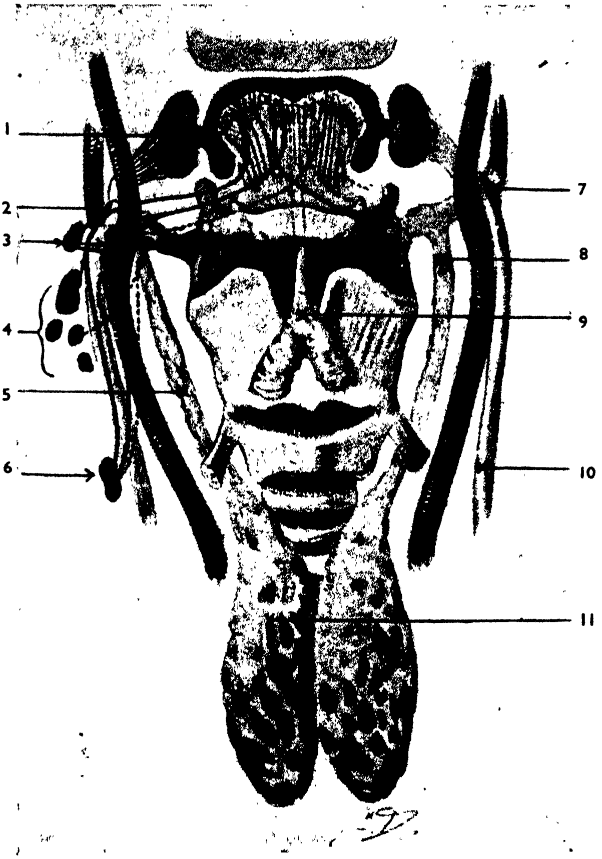

Fig. 824.—Diagram to show position and connections of the various embryological remnants in neck (Dr. S. J. A. Beale), and course of central lymphatics of tongue. (The latter drain into the nodes on both sides of the neck.)

(*Jamieson and Dobson, Brit. Journ. Surg.*)

1, Tonsil; 2, remnant of tonsillar sac (from second cleft recess); 3, submaxillary lymph nodes; 4, upper nodes of deep cervical chain; 5, cervical thymus; 6, lower nodes of deep cervical chain; 7, carotid body; 8, cervical thymus; 9, median part of thyroid and thyroglossal duct; 10, cervical sinus united with second cleft recess on left side; 11, thoracic part of thymus.

and also into the *submental, submaxillary, jugulo-digastric* and *supra-omo-hyoid* nodes on the *opposite side* of the neck.

The vessels from the posterior third of the tongue are larger than those in the anterior two-thirds, and near the middle line pass to both sides of the neck. They pierce the pharyngeal wall and drain into the *jugulo-digastric, the lower nodes of the upper deep cervical chain, and the* *supra-omo-hyoid node.* The lymphatic vessels of the skin and muscles of the neck drain into the *deep cervical* nodes.*

From the upper part of the pharynx the vessels pass to the *retro-pharyngeal* nodes, from the lower part of the pharynx to the *deep cervical* nodes.

The larynx.—There are two sets of vessels. The upper pierces the thyro-hyoid membrane and passes to the *upper deep cervical* nodes; the lower pierces the crico-thyroid membrane and joins the *pretracheal and prelaryngeal* nodes; others pass beneath the cricoid and enter the *lower deep cervical* nodes.

The thyroid gland.—An upper set runs with the superior thyroid artery and enters the *upper deep cervical* nodes; the lower passes to the *pretracheal* nodes and nodes which run with the ascending branch of the inferior thyroid artery, and enters the *lower deep cervical* nodes.

The *supraclavicular* nodes receive afferents from the region just below the clavicle and upper part of the breast. (Gray's Anatomy.)

TREATMENT OF TUBERCULOUS CERVICAL NODES

At the present time there are two schools of treatment of tuberculous nodes in the neck—the *operative,* advocating complete removal of the diseased nodes as soon as possible; the *conservative,* relying mainly on general hygienic measures to bring about a natural cure of the disease, surgical procedures being restricted to aspiration or incision of abscesses, transfixion of the diseased nodes with a seton, and the scraping of sinuses.

Pugh, late of Carshalton, advises the external application of radium. I have not seen any good results from radium and, in any case, it should only be adopted by those experienced in its use.

Improved hygienic conditions, and the early removal of infective foci from the mouth and throat, have diminished the incidence of the disease, and rendered extirpation of tuberculous nodes a rarer operation than it was twenty-five or even fifteen years ago. It is hardly too much to say that no surgeon's education is complete until he has seen the results of advanced conservative treatment of surgical tuberculosis at such an institution as the Treloar Cripples' Hospital at Alton, where the scientific application of rest, fresh air, sunlight, and suitable diet has made such methods more often curative than merely palliative. (*See* Vol. I., p. 34.)

It is interesting to note, as showing the influence of climatic and industrial conditions on the course of the disease, that surgeons in the north of England and Scotland favour early operative treatment, while in the south of England the tendency is towards conservative methods.

The more satisfactory plan is to combine both, confining oneself to conservative measures in the early stages when resolution is possible, and resorting to surgical procedures when the disease is progressive and likely to end in caseation or suppuration and to extend beyond the glands. Both schools are agreed that diseased foci of infection in the throat and mouth—septic tonsils, adenoids and decayed teeth—should be eliminated at the outset of treatment.

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* Jamieson and Dobson, *Brit. Journ. Surg.*, 1920, viii, No. 29, 80.

In some cases, although there may be no physical signs of tuberculosis elsewhere, the type of patient, the signs of intoxication, and the condition of the nodes indicate that the natural course of the disease will end in caseation, sinus-formation, secondary septic infection, and tuberculosis of the skin. Here early removal is indicated.

On the other hand, there are cases in which there is every reason to suspect that the disease has spread beyond the limits of the neck, although the nodes are hard, elastic, and discrete. Here conservative methods should be the primary choice.

In some cases early removal should be undertaken because, even now, tuberculous disease of the neck with suppuration and sinus-formation is frequently seen, in spite of efficient conservative treatment.

More commonly, suppuration and sinus-formation occur where there has been inefficient conservative treatment, or no treatment at all.

Excluding the rarer conditions, seen most commonly in adults, in which the enlarged cervical nodes have become infected secondarily to disease in the mesentery or mediastinum, tuberculous cervical adenitis is in many instances at first a local lesion which can be completely eradicated by excision.

Economic considerations have an important bearing on the choice of the method of treatment.

Selection of the appropriate treatment in individual cases.—In coming to a decision on this question, every aspect of the case must be weighed up carefully, viz. (1) the localization of the disease (the nodes should always be examined with the patient lying down to relax the neck muscles); (2) the patient's general condition as regards tuberculosis and other diseases ; (3) the influence of the local on the general condition, and *vice versa* ; (4) the patient's economic status, home surroundings, family history and responsibilities ; (5) the probable effect of excision on the general condition. The prognosis should be guarded, and the patient or those responsible made to realize that if an operation is carried out it is only one step in treatment, general measures and observation for some years being also essential.

The time taken by conservative treatment is an important consideration to those who cannot afford to suspend their activities at school or daily employment for several months or, possibly, for years. Even those to whom time and money are unimportant may be ill-advised to give up their pursuits for years, when early operation offers them the better prospect of cure. Conservative treatment cannot be relied upon in all cases to clear up the local condition before the disease spreads to other parts of the body and seriously prejudices the general health.

In the course of the so-called natural process of cure, caseation, suppuration, infection of the skin, sinus-formation, and secondary pyogenic infection are quite common. Further, the nodes may become enlarged again from lighting up of the old disease, or from a fresh infection.

It is clear, therefore, that a dissection of the infected nodes should be done when eradication of septic foci in the throat or mouth and careful general treatment do not cause a diminution in their size in a few months, when the disease shows a tendency to spread, and particularly before caseation extends outside the capsule of the nodes, or suppuration takes place. To take some specific examples :

1. *The nodes, though enlarged, are hard, discrete and freely movable.*—Palliative treatment will, in the majority of cases, lead to a rapid diminution in the size of the nodes, and the general health will improve. In others, the nodes will remain enlarged with no sign of matting or caseation. In the minority, the nodes will enlarge and become confluent : in these cases the nodes should be excised before caseation takes place. When there are profound anæmia, enlargement of the glands in the groin and axilla, and a rise of temperature, and probably some enlargement of the spleen, the diagnosis of Hodgkin's disease must be excluded.

2. *An elastic, fixed, ill-defined mass of nodes beneath the sterno-mastoid and deep fascia, with induration of the tissues around the nodes ; the skin over the nodes hyperæmic but freely movable on the deep fascia ; the hyperæmia due to a subacute non-suppurative periadenitis.*—Operation is definitely contra-indicated in such cases as these. Conservative measures will lead to a resolution of the periadenitis, and in the majority of cases the enlargement will subside. Such a periadenitis seems to hasten the natural processes of cure. A similar condition is often seen during treatment by X-rays or by heliotherapy.

3. *A mass of softening nodes attached to the superficial layer of the deep cervical fascia, with infiltration of the skin imminent.*—The nodes should be excised, beginning the dissection where they are not attached to the superficial layer of the deep fascia.

4. *A chronic abscess, not involving the skin, and obviously fluctuating.*—This is a condition frequently found when the source of infection is tonsillar. The contents of the abscess may be quite fluid. Repeated aseptic aspiration will cure the majority of such cases, even when ideal hygienic surroundings are not available.

5. *A fixed mass of nodes under the deep fascia, with a subcutaneous abscess.*—The abscess is opened, the hole in the deep fascia found, and the caseous node just beneath it curetted. The skin is sutured. If the glands do not resolve without signs of further caseation, they should be removed.

6. *A fixed mass of nodes involving the skin, or possibly a sinus.*—The nodes should be removed through an incision avoiding the diseased skin ; the sinus is excised separately. These cases frequently do badly under conservative treatment. The nodes continue to enlarge and

tuberculous may lead to the formation of a localized acute abscess containing fluid (pus), or may hasten the spread of the disease beyond the nodes.

The most common primary sources of infection are the naso-pharynx, diseased tonsils or adenoids ; in other cases the teeth, infection of the scalp (pediculi), or of the external and middle ear, give rise to enlargement of the nodes which is primarily or potentially tuberculous. The intimate association of septic and tuberculous infection makes it difficult to decide when the nodes are in a condition of chronic septic inflammation and when they are tuberculous. For practical purposes we may regard all lymph-nodes as tuberculous which are still enlarged or increasing in size four to eight weeks after all possible foci of septic infection have been removed. If syphilis be excluded, persistent hyperplasia of the cervical lymphatic nodes is practically always tuberculous, persistent enlargement of non-tuberculous septic nodes after the primary focus has been removed being so rare as to be negligible. Grey Turner has frequently referred to this question. His views* are epitomized as follows :

There are two great groups of patients in whom the cervical nodes become tuberculous. In one the infection is local and arises from the tonsils, naso-pharynx or, more rarely, from the teeth, and in the other a primary infection of the mesenteric or mediastinal glands is the portal of entry. The clinical features of the two groups are as follows :

Naso-pharyngeal group.—

(1) Begin to give trouble in the early years of life before puberty.
(2) Often associated with a throat illness.
(3) Tonsils usually enlarged or adenoids present or both.
(4) First noticed in upper part of the neck and, after onset, general health not much affected.
(5) Not usually calcified.
(6) No evidence of tuberculosis elsewhere.
(7) Prognosis after radical operation uniformly good.

Mesenteric or mediastinal group.—

(1) Become active after puberty or later.
(2) Not associated with throat illnesses.
(3) Tonsils not usually enlarged, adenoids not present.
(4) First noticed in the root of the neck. Often associated with enlarged nodes in the axillæ or groins.
(5) General health usually poor.
(6) Often calcified.
(7) Often clinical or X-ray evidence of tuberculous nodes in the mediastinum or mesentery.
(8) Prognosis always uncertain.

In the naso-pharyngeal group, any existing source of infection, such as tonsils and adenoids, must be removed first. If, after treating the focus, the enlargement does not rapidly disappear, then the best plan is to carry out a thorough surgical removal and, by a carefully planned dissection, clear out the highest part of the carotid triangle. This may have to be done on both sides.

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* *Newcastle Med. Journ.*, July, 1931, ii, 145

In the mediastinal or mesenteric group radical removal should never be carried out in the first instance. General hygienic measures are the first essential, but surgical intervention may be necessary if the nodes remain persistently tender or break down or if there are repeated attacks of periadenitis, or if, after the general infection is presumably quiescent, a mass of nodes remains as an unsightly annoyance.

REMOVAL OF TUBERCULOUS LYMPH NODES

The surgeon having decided, after carefully weighing the clinical, pathological and economic factors of the case, that the diseased nodes should be excised, the future history, so far as he is concerned, will depend on four essentials—(1) a rigid aseptic technique ; (2) an accurate knowledge of the anatomy of the neck ; (3) complete removal of all nodes in the region operated on, and not merely those which are obviously diseased, and (4) efficient after-care.

(1) *Asepsis.*—To secure primary union of the wound and minimize auto-inoculation, the tissues should be treated with the utmost gentleness. Grossly-damaged tissues will be more vulnerable to septic organisms gaining access from without, and to tubercle bacilli and their toxins, which are bound to escape in small numbers from the nodes and divided lymphatics even at a carefully conducted and gentle operation. Strong coagulating antiseptics should not be swabbed over the surface of the wound to destroy escaped bacilli : they injure the tissues they are designed to protect, and increase the local inflammatory reaction.

The dissection should be carried out with knife and scissors, the temptation to dislodge the nodes with the fingers being studiously resisted. They must be removed *en masse* with the cellular tissue and fat in which they lie. The surgeon should be in no hurry and should clear out the whole of an infected group, or rather anatomical group, with a margin of unaffected nodes. Important nerves must not be sacrificed.

(2) *Anatomical knowledge.*—This subject has already been considered.

(3) *Complete removal of the diseased nodes.*—It must have been the experience of all surgeons at one time or another to have patients on whom they had operated a few months previously returning with a recurrence of enlarged nodes beneath or near the scar. Presuming that the primary focus has been removed, such recurrence is serious, because it shows either that the infection was virulent, or that there is a lack of resistance. It must be remembered that the extent of disease in the neck bears no direct relation to the degree of general ill-health. One small infected node left behind is a focus from which the disease may spread to nodes lower down in the chain, or to other parts of the body. If operation is undertaken at all, it must therefore be with the definite object of removing all the infected nodes.

(4) *After-care.*—Although the surgeon may feel that he has removed

the focus of disease after extirpating nodes such as the naso-pharyngeal group, tuberculous infection is so insidious in its course and protean in its manifestations as to shake confidence in the permanence of any measure designed to eradicate it, however sound in conception and complete in execution.

Whenever possible the patient should live in the country or at the seaside under good hygienic conditions for at least six weeks—or longer—after discharge from hospital, and on his return to his usual life must continue to observe good hygienic conditions under medical supervision. If in four or five years there is no return of symptoms, the surgeon may be optimistic and hope that the disease has been eradicated and that the patient is more resistant to fresh infection than before.

Preparation of the patient.—Attention having been paid to the throat and teeth, the patient should be admitted to hospital at least twenty-four hours before the proposed operation, to get used to his surroundings and to enable a thorough general examination (particularly of the throat, mouth and lungs). If a purge is necessary, it should be given on the morning of the day before operation. A strong purge given the night before an operation is bad and inconsiderate treatment.

Preparation of the area of operation.—The lower part of the scalp behind the ear is dry-shaved, and the whole of the neck and lower part of the face on the diseased side is wrapped in an antiseptic compress at least twelve hours before operation. In adults the skin is washed with acetone, painted with tincture of iodine or 2-per-cent. picric-acid solution, and covered with a dry, sterile compress. In young children, iodine irritates the skin, and plain spirit may be used instead.

Half an hour before the operation, a child should be given $\frac{1}{200}$ gr., and an adult $\frac{1}{100}$ gr., of atropine sulphate, hypodermically, to diminish mucous secretion. If not particularly contra-indicated and if the anæsthetist wishes it, $\frac{1}{8}$ or $\frac{1}{4}$ gr. of morphia may also be given to adults, but scopolamine should not be used, even in nervous patients, on account of its tendency to cause cyanosis and unnecessary hæmorrhage.

The anæsthetic.—These operations do not lend themselves to any form of local anæsthesia, but some surgeons favour rectal anæsthesia in order that the anæsthetist may be kept away from the operation area. Any general anæsthetic may be given, but marked venous congestion must be prevented, as it hampers the operator. The risk of sepsis, consequent on the close proximity of the anæsthetist to the field of operation, is most easily overcome by intratracheal ether or nasal anæsthesia, but if these are not available a clean field is obtained by fixing a semicircular hoop of metal to the operating-table, or by so placing an anæsthetic cage over the head that it lies at the level of the mouth. Sterile towels are arranged over the hoop to shut off the anæsthetist without interfering with his access to the face and upper air-passages. (Fig. 825.) One towel hangs vertically from the loop or cage and is fixed with towel clips to the chin, just below the lobule of the ear, and to the external occipital protuberance. Failing a hoop or cage, the surgeon lays the upper half of a sterile towel over the face, the anæsthetist then grasps the symphysis of the jaw, and the lower part of the towel is thrown over his hand. (Fig. 826.)

Instruments.—In addition to the general set, the following are required : two pairs of node-holding forceps, a pair of Mayo's dissecting scissors, blunt-pointed and curved on the flat, and at least two dozen pairs of curved artery-forceps, Kocher's or Sargent's. The latter artery-forceps are particularly useful to fix the towels to the platysma and subcutaneous tissues when shutting off the skin from the wound, because they lie conveniently out of the way, with the points concave downwards in the wound.

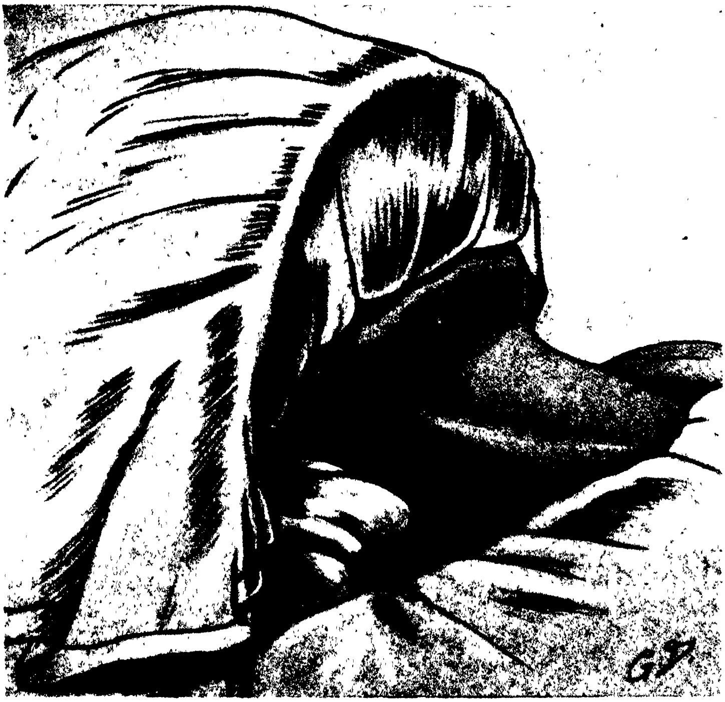

Fig. 825.—Arrangement of sterile towels over semicircular hoop of metal, completely to shut off field of operation.

Positions of patient and surgeon.—The patient lies in the dorsal position with a small hard pillow under the neck and the face turned away from the side requiring operation. The arm on the affected side is drawn well down and fixed by the side of the trunk, with the hand under the buttock. The hair and scalp are enclosed in a rubber cap, and sterile wool is placed under the neck to absorb blood. The head is raised from the table, and two sterile towels are held under the head and neck; the lower one is dropped on the operating-table and the upper one is folded round the head and fixed over the forehead. The metal hoop is then fixed over the head, and sterile towels are arranged to cover everything except the field of operation.

The surgeon stands on the side to be operated on, with the first assistant on the opposite side; a second assistant should stand next to the surgeon at the head of the table.

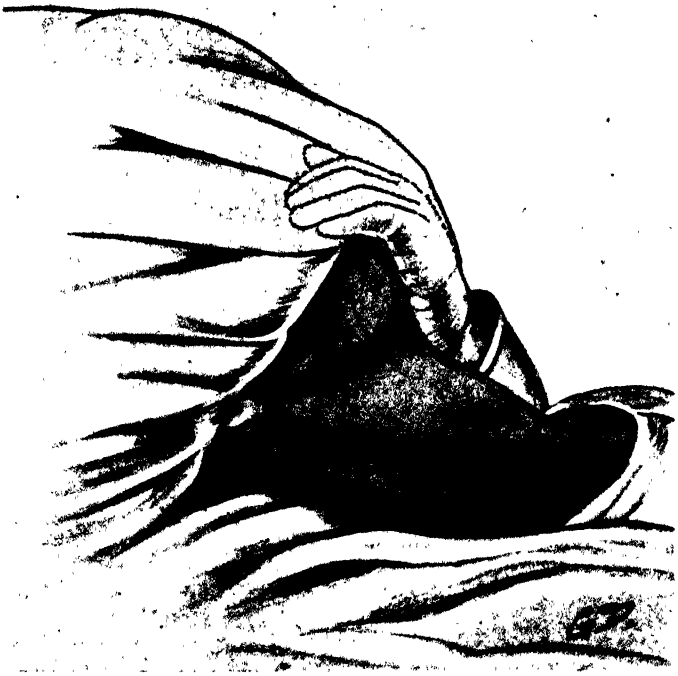

Fig. 826.—Arrangement of sterile towels without metal hoop, completely to shut off field of operation. Anæsthetist's left hand is outlined beneath towel.

The incision.—The position of the incision will vary according to the site and size of the masses, but in all cases incision must be free, because the disease is always much more extensive than external examination suggests. Further, the aim of the operation is to remove all the diseased nodes, to prevent unnecessary hæmorrhage by seeing and picking up vessels before dividing them, and to dissect important structures from the nodes without injuring the edges of the skin incision or the deeper structures by excessive traction. Hæmostasis and due regard to the anatomy of the parts are impossible through a small incision. As a general rule, the incisions should follow the principles laid down by Kocher and lie in or parallel with the normal creases or folds in the neck and correspond to the lines of stress. Such scars in course of time become almost invisible, and do not stretch. Vertical incisions at right angles to the clavicle should be avoided whenever possible: they tend to stretch, and in children, and in adults with short thick necks, they do not give such a good exposure as transverse or oblique incisions. Triradiate incisions meeting at an acute angle do not heal well; the points may slough and lead to ugly depressed scars. A few scratch marks should be made with a cutting needle at right angles to the direction of the incision to act as a guide for placing the sutures in order to secure accurate coaptation of the skin independently of the position of the head. By keeping well behind the angle of the jaw and below the body of the hyoid bone, the nerve supply to the depressor labii inferioris and risorius is preserved in the upper flap.

The various incisions are described when dealing with the removal of glands in the separate regions (Figs. 829 and 831). A block dissection of all the cervical nodes can be made through two incisions—an *upper incision*, starting well behind the ear in the hairy part of the scalp, passing at least an inch below and behind the angle of the jaw downwards below the body of the hyoid bone, and curving forwards and slightly upwards to reach the middle line just above the thyroid cartilage; and a *lower incision*, beginning over the anterior part of the trapezius, 2 in. above the clavicle, and passing downwards and forwards to and near the middle line of the neck, 1 in. above the sternum. If more room is required, the posterior end of the lower incision may be curved upwards and forwards along the anterior border of the trapezius. The naso-pharyngeal and lower nodes of the vertical chain may be removed through a ſ-shaped incision. The horizontal limb commences just below the body of the hyoid bone, passes backwards and upwards 1 in. behind the angle of the jaw to just below the mastoid process, and then curves gently backwards into the vertical limb, which runs down the posterior triangle of the neck, parallel with and 1 in. in front of the anterior border of the trapezius.

Technique.—The superficial fascia and platysma are divided along the whole length of the wound; hæmorrhage is usually free until the platysma has been divided. The superficial bleeding-points are picked up and ligatured with very fine catgut. The skin is then shut off from the depths of the wound with two towels fixed to the subcutaneous tissues (not to the skin) with curved artery forceps, and at each end of the wound with a pair of tissue forceps. (Fig. 827.) The deep fascia is divided with a fresh knife, and flaps of skin, superficial and deep fascia, are raised until well beyond the superficial limits of the disease.

Vessels are tied off with catgut during the dissection, so that the manipulations are not interfered with by an accumulation of artery forceps. The assistant should have a pair of dissecting forceps in his left hand throughout the operation, and with these should swab the wound dry with firm momentary pressure, and not by continuously rubbing or lightly wiping its surface. The dissection is then carried into the loose connective tissue surrounding the capsule of the nodes, commencing at a point where they are not adherent to the deep fascia. In freeing the nodes, care must be taken to be in the right layer. If in the right layer, the nodes are easily dissected off by snipping the connective tissue round their capsules with Mayo's scissors and then opening the blades of the scissors, repeating this manœuvre systematically, without removing the scissors from the wound, until a definite piece of work has been done. Blunt dissection must not be carried out with the handle of the knife or the fingers. The nodes must not be forcibly avulsed and freed by cutting blindly in the depths of the wound. In this way large veins (which when stretched look like connective tissue) and nerves may be injured, and hæmorrhage, even from small vessels which have retracted and become buried in the depths of the wound, can only be arrested with difficulty and tedious waste of time. If the nodes are adherent, they must be dissected off with the scissors or a sharp scalpel, the cutting edge directed towards them. Node-forceps should be dispensed with altogether, or at any rate only be used in the later stages of the operation, because they are likely to burst the nodes and set free infected material.

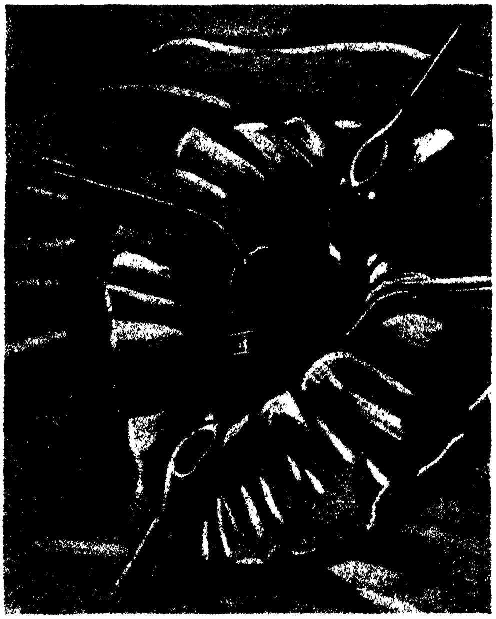

Fig. 827.—Method of protecting wound from skin.

Any remaining bleeding vessels are tied with catgut. Care should be taken that the wound is quite dry, and that there are no large open veins which may bleed as soon as the patient comes round from the anæsthetic. It is sometimes recommended that the patient be made to cough or strain just before the wound is closed, to show up any unsecured veins, a proceeding which may have embarrassing consequences at the time but which prevents the subsequent development of hæmatoma.

In extensive operations, where there is much oozing, and to prevent the accumulation of lymph which escapes from the divided lymphatics into the dead spaces of the wound, a small rubber-glove drain is brought out of the most dependent part of the wound through a separate small incision. This drain is usually removed in twenty-four or forty-eight hours. A stiff rubber tube may cause hæmorrhage by ulcerating into the vessels lying unprotected in the wound.

The deep fascia, superficial fascia, and platysma on each side of the wound are accurately coapted with a single layer of interrupted catgut sutures, arranged so that the corresponding scratches in the skin are in accurate apposition. The skin-edges are everted and brought together with Michel's clips or with a subcuticular stitch of silkworm-gut; a small piece of this material should be placed under the centre of this stitch, to facilitate its removal in two halves. The ends may be secured by knotting, or by threading a small lead shot on each and compressing them with special forceps.

The dressing.—The wound is covered with a copious dressing of dry sterile gauze and plenty of wool, pressure being kept on the wound until the dressings are securely bandaged. The wool and bandages are not merely to fix the dressings and prevent access of septic organisms, despite movements of the head, but are designed to act as a splint to secure proper rest to the injured tissues. A simple spiral is not satisfactory; the bandage should commence with spiral turns directed forward from the side operated on, carried downward as a figure-of-eight round the neck and axilla, then brought upwards as a spiral round the neck, going over the top of the head in front of and behind the ear, followed by a few turns round the forehead. (Fig. 828.) Pins are fixed where the turns of the bandage cross one another. The pressure of the bandage may cause blueness of the face, until the patient comes round from the anæsthetic.

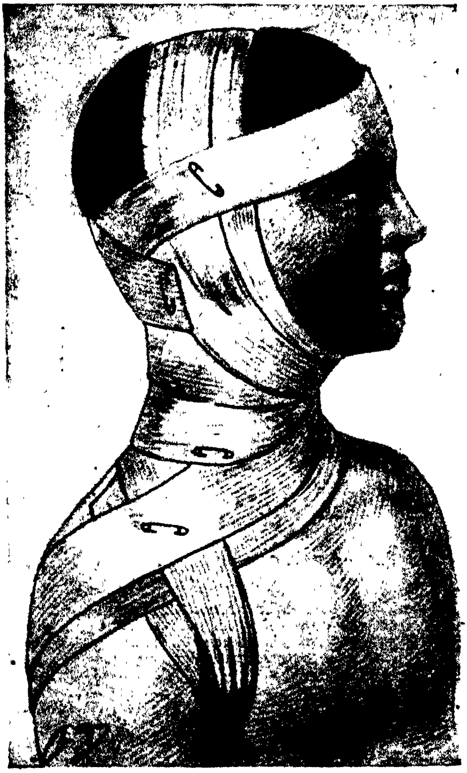

Fig. 828.—The bandage.

After-treatment.—The patient is put back to bed in the dorsal position, with the head turned away from the diseased side, and must not be left until quite conscious. A tongue forceps and gag should be ready in case of respiratory embarrassment. Even in children, where a proportionately large area of the body has been exposed, there is rarely severe collapse or shock. Rectal saline at 110° F., with aspirin or bromide, should be given in quantities of one pint at a time during the first thirty-six hours, to supply fluid during the period when swallowing may be painful. Intravenous or subcutaneous salines should not be given because they increase the exudate from the divided lymphatics in the wound and favour sepsis. The unpleasant taste of the anæsthetic is eliminated by giving the patient a small piece of lemon to suck or a little vinegar to sip.

The first dressing to remove the tube must be conducted aseptically; it is a disadvantage of drainage that the dressing must be disturbed so soon. In uncomplicated cases the wound should not be examined before the seventh to the tenth day, when the stitches are removed.

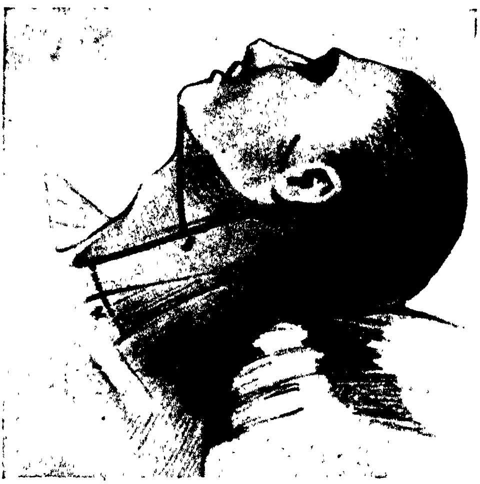

Fig. 829.—Incisions for removal of cervical lymph nodes.

1, Parotid or pre-auricular; 2, occipital; 3, submaxillary and anterior deep cervical nodes; 4, incision made, when necessary, to give access to lower nodes of vertical chain; 5, posterior auricular or mastoid.

Local rest should be maintained for at least a fortnight; the patient, although sitting up after the first twenty-four hours, must have the head and neck supported by pillows.

Small exudations of lymph in the wound are usually absorbed without drainage, but a collection large enough to produce tension on the stitches must be let out with sinus forceps.

Incisions for removal of the different groups of nodes. *The pre-auricular or parotid nodes.* (Fig. 829, 1.)—The superficial nodes are removed through a transverse incision just in front of the ear. The pes anserinus lies beneath the glands in the substance of the parotid, and Stenson's duct is on a deeper plane and in front.

The *postauricular nodes* are removed through a transverse or vertical incision just behind the ear. (Fig. 829, 5.)

The *occipital nodes* (Fig. 829, 2) may be removed through an incision running downwards and forwards from the anterior border of the trapezius. The great occipital nerve and occipital artery lie deep to the nodes.

The *superficial cervical nodes* are removed through a transverse incision over the upper part of the posterior triangle and sterno-mastoid muscle.

The *submental nodes* are removed through an incision just below and parallel with the mandible, or through a vertical incision from the symphysis menti to the hyoid bone. The mylo-hyoid nerve and artery lie deep to the nodes.

Submaxillary nodes.—The excision of the submaxillary nodes (Fig. 831, 1) is described with removal of the upper nodes of the deep cervical chain (*see* below).

In removing tuberculous nodes, the cervical branch of the facial nerve may be injured (*a*) where it lies beneath the deep fascia in the parotid region, (*b*) after it has pierced the deep fascia just below and behind the angle of the jaw, (*c*) in the region of the hyoid bone, or (*d*) by incisions which pass behind a line running vertically downwards from just in front of the point where the facial artery crosses the mandible to the hyoid bone. (Fig. 830.)

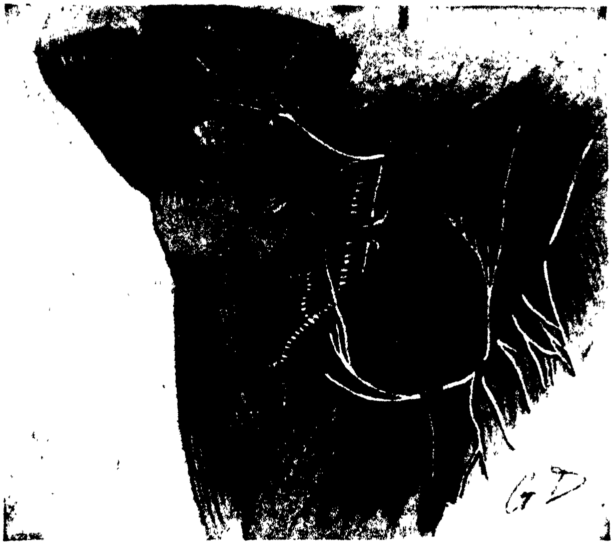

Fig. 830.—Cervical branch of the facial nerve.

By making the incision well behind the angle of the jaw, below the body of the hyoid, and carrying it forwards in front of the facial vessels the nerve supply to the depressor labii inferioris is preserved in the upper flap.

In order to avoid the superficial parts of the nerve in removing the submaxillary nodes, the incision should commence just below and behind the tip of the mastoid process, curve downward and forward at least an inch behind and below the angle of the mandible until below the level of the hyoid bone, then forward, and finally upward towards the symphysis. The platysma and skin must not be separated but must be turned up together. The deep part of the nerve may be unavoidably injured when dissecting adherent nodes from the lower part of the parotid triangle. The paralysis is rarely permanent because filaments from the mandibular branch of the facial usually supply the depressor anguli oris and upper part of the platysma, through the branches to the risorius muscle.

The submaxillary and upper deep cervical nodes may be removed through an incision shaped as in Fig. 831, 3, the vertical limb lying behind the sterno-mastoid parallel with the anterior border of the trapezius, and a horizontal limb carried forwards to just below the symphysis.

As a general rule, incisions running parallel to the whole length of the sterno-mastoid are not required for the removal of tuberculous nodes.

Excision of the upper cervical nodes.—Enlargement of the nodes of the upper deep cervical chain leads to the formation of a tumour projecting in front of, beneath and behind the sterno-mastoid muscle, with a chain of nodes running downward in the posterior triangle.

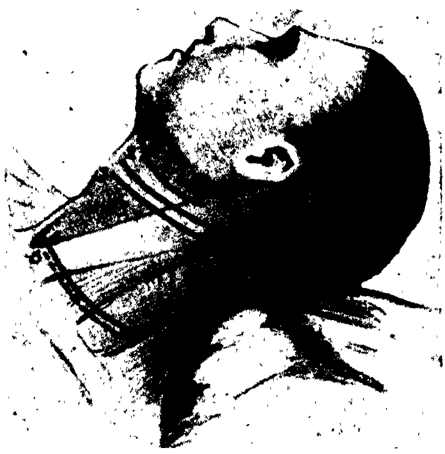

Fig. 831.—Incisions for removal of cervical glands.

The incision begins well behind the ear in the hairy part of the scalp (Fig. 831, 2, 3), and curves forwards and downwards to the thyroid cartilage, and then upwards to the hyoid bone. The external jugular vein running vertically downwards across the sterno-mastoid, and the anterior jugular vein in the front part of the incision, are secured, divided, and ligatured, and then the incision is carried down to the deep fascia along its whole length. The lower part of the cervical division of the facial nerve and the ascending branch of the transverse cervical nerve are divided. The great auricular, passing upwards and forwards towards the ear, and the small occipital nerve running along the posterior border of the sterno-mastoid, are exposed, and need not be divided at this stage, though division may be inevitable later. When operating for nodes that are not neoplastic it should be a rule to spare all nerves that are not actually involved by the disease process. Flaps of skin and superficial fascia are reflected upward and forward, and backward and downward, until well beyond the superficial limits of the disease. The sterno-mastoid muscle is defined, and an incision is made through the deep fascia at its anterior border, and the deep surface of the muscle is dissected off its sheath. The spinal accessory nerve is exposed where it enters the deep surface of the sterno-mastoid from behind the posterior belly of the digastric, at a point one inch below the tip of the mastoid, on a level with the lateral mass of the atlas. (Fig. 832.) The sterno-mastoid branch of the occipital artery runs into the muscle just superficial to the spinal accessory nerve, and serves as a guide. The nerve is dissected free from the nodes with a few touches of the knife.

The sterno-mastoid is retracted backward and downward, and the nodes are exposed as far as possible. If the lower and backward limit of the disease is not easily accessible, the posterior border of the sterno-mastoid is defined. The superficial branches of the cervical plexus emerge from behind the middle of the posterior border of the muscle, and one of the descending cutaneous branches may be mistaken for the spinal accessory nerve. The spinal accessory usually lies superficial to the nodes at the junction of the upper and middle thirds of the muscle. The nerve must be carefully preserved, though the cutaneous branches will probably be divided.

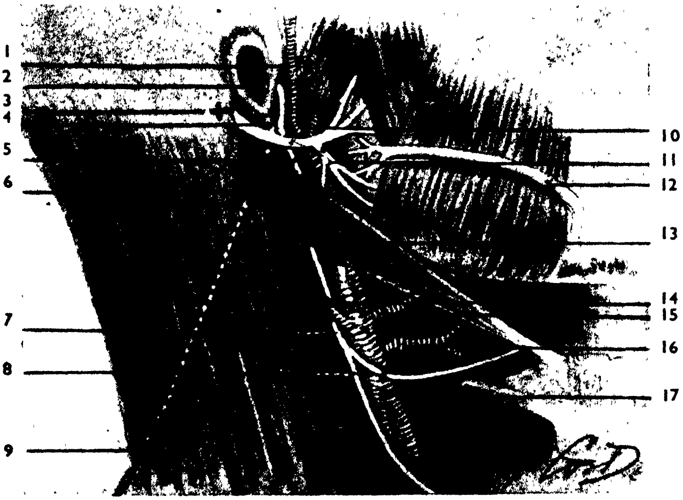

Fig. 832.—Facial, spinal accessory, and hypoglossal nerves.

1 Superficial temporal artery ; 2, external auditory meatus ; 3, surface marking of facial nerve at midpoint of anterior border of mastoid process ; 4, styloid process ; 5, hypoglossal nerve ; 6, upper surface marking of spinal accessory nerve, 1 in. below mastoid process and just below transverse process of atlas vertebra ; 7, hypoglossal nerve ; 8, hypoglossal nerve ; 9, lower surface marking of spinal accessory at posterior border of sterno-mastoid ; 10, internal maxillary artery ; 11, facial nerve ; 12, Stenson's duct ; 13, digastric muscle ; 14, occipital artery ; 15, facial artery ; 16, lingual artery ; 17, external carotid artery.

The muscular branches of the cervical plexus from the 3rd and 4th cervical nerves, which run parallel with and just below the spinal accessory nerve, should be preserved. (Fig. 834.) They are usually smaller than the spinal accessory, but in some cases they are larger and contain most of the afferent fibres to the trapezius. The posterior limit of the disease is defined, the sterno-mastoid is retracted forward, and the nodes in the posterior triangle are dissected off the complexus, splenius, and levator anguli scapulæ muscles. The sterno-mastoid is then retracted backward, the anterior belly of the omo-hyoid displaced downward and forward, and the internal jugular vein is deliberately exposed by dividing the sheath of deep cervical fascia lying over it. The nodes lying free in the posterior triangle are displaced in front of the sterno-mastoid. If they are not adherent to the wall of the vein, they will strip up easily as soon as the sheath is divided. As they are dissected upward off the vein, the operator will come successively on the ansa hypoglossi, the middle and superior thyroid veins, the lingual vein, and the common facial vein. The common facial vein is usually divided in order to free the tonsillar

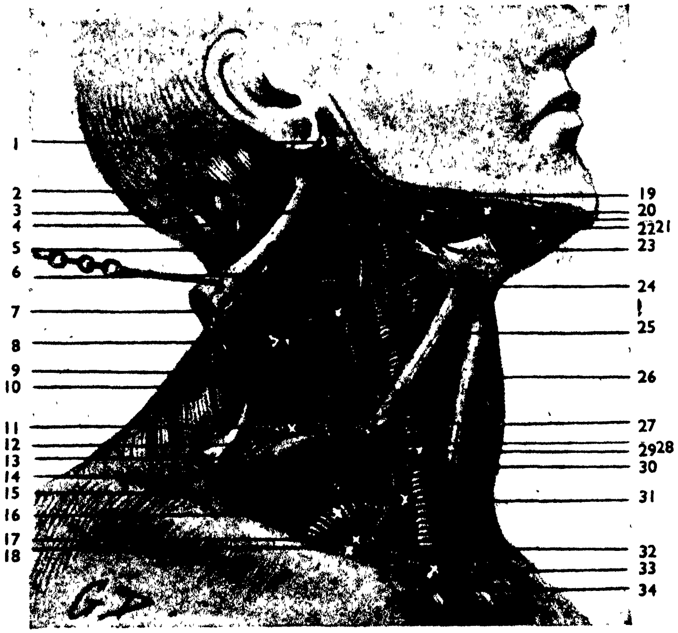

Fig. 833.—Muscles and vessels of neck.

1, Temporal vein; 2, sterno-mastoid muscle; 3, posterior belly of digastric; 4, complexus; 5, splenius capitis; 6, sterno-mastoid; 7, external jugular vein; 8, posterior jugular vein; 9, levator anguli scapulæ; 10, trapezius; 11, transversalis colli vein; 12, posterior scapular vein; 13, posterior scapular artery; 14, scalenus medius; 15, scalenus medius; 16, subclavian artery; 17, suprascapular vein; 18, suprascapular artery; 19, stylo-hyoid; 20, facial artery; 21, facial vein; 22, anterior belly of digastric; 23, mylo-hyoid muscle; 24, thyro-hyoid muscle; 25, anterior belly of omo-hyoid; 26, sterno-hyoid; 27, common carotid artery; 28, posterior belly of omo-hyoid; 29, middle thyroid vein; 30, scalenus anticus; 31, internal jugular vein; 32, communication between anterior jugular veins; 33, branch to sterno-mastoid from suprascapular artery; 34, sterno-mastoid.

lymphatic nodes; the hypoglossal nerve lies immediately beneath the common facial vein.

The nodes have now to be cleared above and in front. The upper part of the sterno-mastoid is retracted backwards and the nodes are stripped off the internal jugular vein until the lower border of the posterior belly of the digastric is reached; the spinal accessory nerve is cleared and the dissection on a more superficial plane carried into the lower part of the parotid gland. The main trunk of the facial nerve issuing from the stylo-mastoid foramen lies above the posterior belly of the digastric, but farther forward, near the mandible, and should never be seen. The cervical division of the facial lies on the parotid gland just beneath the superficial layer of the deep fascia, and may be injured, particularly if the nodes are adherent. The temporo-maxillary vein is usually divided where it lies in the substance of the parotid on a deeper plane to, but below, the facial nerve. As one dissects forwards in the upper part of the carotid triangle, the nodes lie immediately superficial to the hypoglossal nerve, the occipital artery, and the external carotid artery.

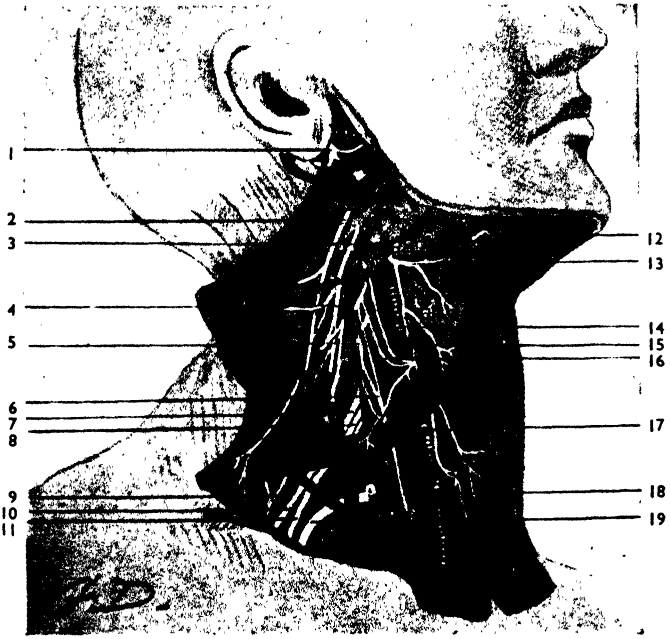

Fig. 834.—Nerves of neck.

1, Facial; 2, spinal small accessory; 3, anterior division of 2nd cervical; 4, anterior division of 3rd cervical; 5, anterior division of 4th cervical; 6, phrenic nerve; 7, anterior division of 5th cervical; 8, anterior division of 6th cervical; 9, suprascapular; 10, upper trunk of brachial plexus; 11, middle trunk of brachial plexus; 12, mylo-hyoid; 13, hypoglossal; 14, descendens hypoglossi; 15, anterior belly of omo-hyoid; 16, communicantes hypoglossi; 17, anterior division of 7th cervical; 18, phrenic; 19, lower trunk of brachial plexus.

Removal of the submaxillary nodes.—The facial artery enters the submaxillary gland at the anterior border of the posterior belly of the digastric and stylo-hyoid muscle, and lies on a more superficial plane than the ranine vein and hypoglossal nerve. The superficial part of the submaxillary salivary gland is removed with the lymphatic nodes in order fully to expose the anterior group of submaxillary lymphatics which lie under the mandible. The facial artery should be divided and ligatured if the nodes are adherent to the posterior belly of the digastric and stylo-maxillary ligament. The hypoglossal nerve and ranine vein lie deep to the fascia covering the hyo-glossus and, therefore, escape injury. Farther forward the lingual nerve, the deep part of the submaxillary gland with Wharton's duct, the hypoglossal nerve, and the ranine vein lie deep to the mylo-hyoid muscle. If the deep part of the submaxillary gland is removed, Wharton's duct should be ligatured. Towards the front of the area the anterior belly of the digastric is exposed, and by dissecting beyond this muscle, i.e. between it and its fellow, the submental nodes lying on the mylo-hyoid may be removed.

The submaxillary nodes are dissected free from the mandible, the facial vessels being secured and divided. The glandular mass is then removed and any remaining bleeding-points are ligatured. When the wound is quite dry the layers are sutured, with a glove drain through a small incision in the most dependent part of the wound.

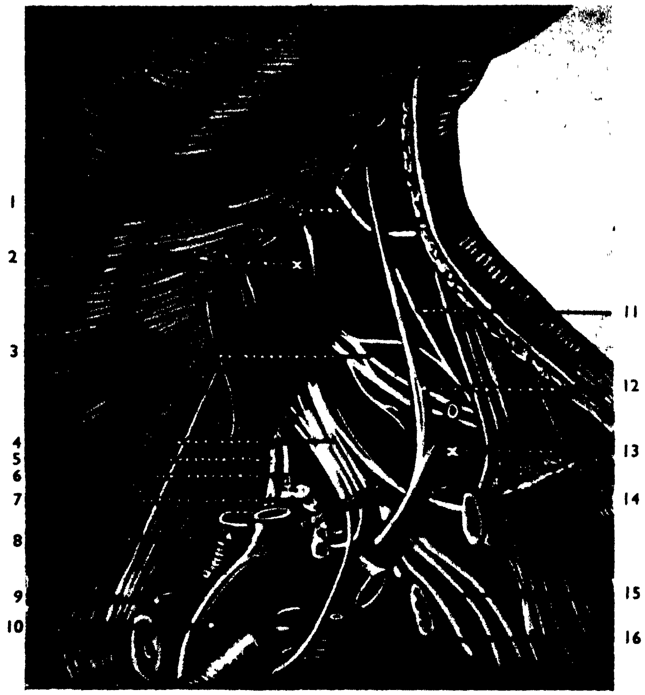

Fig. 835.—Dissection of left side of neck, showing thoracic duct.

perficial cervical nerve ; 2, clavicular part of sterno-mastoid ; 3, descending muscular branches from 3rd and 4th cervical nerves ; 4, brachial plexus ; 5, vagus nerve ; 6, phrenic nerve ; 7, thoracic duct ; 8, common carotid artery ; 9, anterior jugular vein ; 10, left innominate vein ; 11, spinal accessory nerve ; 12, external jugular vein ; 13, omo-hyoid muscle ; 14, clavicle ; 15, 1st rib ; 16, dome of pleura.

Excision of the lower cervical nodes.—A curved incision is made (Fig. 831, 4, 5), commencing over the anterior part of the trapezius 2 in. above the clavicle, and passing forward and downward to or near the middle line of the neck, 1 in. above the sternum. If more room is required, the posterior end of the incision may be carried upward and forward along the anterior border of the trapezius. The external jugular vein is divided between ligatures at the posterior border of the sterno-mastoid just before it pierces the deep fascia. The incision divides the descending cutaneous branches of the cervical plexus.

The upper flap is dissected upward and forward, exposing the lower part of the sterno-mastoid muscle, the anterior border of the trapezius, and the posterior triangle. The lower flap is dissected down to the clavicle, exposing the lower and anterior part of the trapezius muscle ; the cephalic vein is ligatured before it pierces the deep fascia. The spinal accessory nerve crosses the upper part of the incision and is dissected free. During the operation it may be necessary to divide the anterior fibres of the trapezius and clavicular fibres of the sterno-mastoid transversely just above the clavicle. The deep fascia is divided transversely at the same level, and the nodes immediately come into view. Dissection is carried on below, and deep to the nodes, until the posterior belly of the omo-hyoid is exposed by dividing the fascia which binds that muscle to the clavicle. The omo-hyoid is dissected free from the nodes and drawn downward, while the anterior border of the trapezius is cleaned and the nodes beneath that muscle, and behind the clavicle on the upper part of the serratus magnus, are dissected free from the cellular tissue with Mayo's scissors. The suprascapular and transversalis colli veins must be secured.

The dissection is now carried upward on the scalenus medius until the upper limit of the disease is reached, and then forward beneath the sterno-mastoid. The omo-hyoid is retracted upward, and the internal jugular vein is exposed. The terminal parts of the transversalis colli and suprascapular veins are ligatured just where they enter the external jugular vein, the transversalis colli artery is secured and ligatured, and the glandular mass is then turned forward, exposing the brachial nerve-trunks. Farther inward, the phrenic nerve, the ascending cervical artery, and the lower part of the internal jugular vein will be found lying behind the nodes. The sterno-hyoid muscle, sterno-thyroid muscle, and the terminal part of the anterior jugular vein lie in front of them. The nodes are dissected off the internal jugular vein until the subclavian vein is exposed. The vagus nerve lies behind the internal jugular vein, and in front of the vertebral vein, and will not be injured if care be taken to keep close to the capsule of the nodes, even when they are found to extend behind the internal jugular vein. In dissecting behind the internal jugular, the white beaded thoracic duct may be seen, and care must be taken not to divide it. When all the cervical nodes are removed through two transverse incisions, the nodes freed through the upper incision are pushed downward into the lower wound, and all are taken away *en bloc*.

A glove drain is brought out through a small incision just above the middle of the clavicle.

Difficulties in operations on the cervical nodes.—Apart from working through too small an incision, these difficulties are usually due to caseation and softening, periadenitis leading to adhesion to surrounding structures, and spread of the disease to and through the deep fascia, with infiltration of the blood-vessels, nerves, and muscles and, finally, ulceration of the skin with secondary septic infection.

Hæmorrhage.—With a good exposure, the arteries are easily secured, but venous blood welling up from the depths of the wound may be difficult to control. This may invariably be prevented by dissecting the nodes *in situ* as far as possible, remembering that traction on the nodes empties the veins, and gives them the appearance of bands of fibrous tissue and renders them extremely liable to button-holing.

Dissecting the nodes off the internal jugular vein.—Adhesions, if present, are in most cases outside the sheath of the jugular vein, so that, by exposing the vessels beyond the diseased nodes, they are readily freed by dissecting with a knife or Mayo's scissors. Care must be taken not to dissect in the wrong layer, too far from the sheath. When the sheath is adherent to the jugular vein the nodes can usually be freed by careful and patient dissection. If they are very firmly adherent, before attempting to dissect them away the upper end of the vein beyond the disease should be exposed, to minimize the risk of severe hæmorrhage from accidentally wounding it. The nodes are then dissected off from below upwards, securing branches joining the vein, before dividing them, and, if the nodes are adherent, securing with artery forceps the portion of wall just beyond them before cutting them away. A small hole in the vein may be closed by a lateral ligature, but care must be taken that such ligatures, particularly if of catgut, are secure. Fine silk or linen thread is better for this purpose. If this is doubtful, or the hole is too large for a lateral ligature, the vein must be tied above and below the opening. The inner coats of the vein may herniate through a rent in the outer coats, in which case the vein should be ligatured above and below the hernia. With experience of the operation, the jugular vein need rarely be sacrificed. Ligature of the vein, and peeling it upward off the vagus, carotid, and sympathetic, make removal of the nodes easier, but should not become a routine because, apart from the needless sacrifice of an important anatomical structure, removal of both veins may have serious consequences to the intracranial circulation if the glands on the other side of the neck are removed later. Sutcliffe* reported that in 250 operations for excision of tuberculous nodes, he found it necessary to ligature the vein in only four cases. Watson Cheyne found that removal of a large part of the vein with the nodes was harmless, and Stiles† recommends its removal when the nodes cannot be dissected off its wall.

When the nodes are large enough to press on the jugular vein, the collateral circulation through the opposite internal jugular and vertebral veins will be developing before the operation.

Difficulty may be experienced in securing the upper end of the external jugular and temporo-maxillary veins in the parotid gland, because the bleeding vessels retract into the fibrous stroma and are prevented from collapsing. They may be secured by forceps clamping some of the gland tissue, and then underrunning the vessels with a suture on a needle, before tying.

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* *Lancet*, Nov. 14, 1903, ii, 1351.
† *Brit. Med. Journ.*, Sept. 12 .1896, ii, 610.

In the lower part of the neck slight wounds of the external jugular vein and the plexus of veins in the supraclavicular fossa, the suprascapular, transversalis colli and cephalic, may cause troublesome hæmorrhage. This may be prevented by securing the lower part of the external jugular between ligatures and picking up the branches to that vessel with forceps before dissecting the nodes.

Air embolism.— If traction is made on the nodes and their deep attachments are divided, air may be sucked through a hole in a large vein into the circulation. This accident rarely happens, because the wound is full of blood by the time the injured vessel has fallen into its depths. After firm pressure with a sponge, the wounded vessel must be secured. It is a good plan to have a bowl of saline in readiness to pour into the wound should this accident occur. If the patient should show severe cyanosis and collapse, the vein may be emptied of air by squeezing the chest during expiration (Treves and Hutchinson). When the hissing sound of air entering a large vein is heard, the assistant must at once apply pressure on the wounded area with a wet swab. The internal jugular vein is compressed above and below the injured area. The assistant then removes the swab, and the opening in the vessel is secured with artery forceps and ligatured.

Wounds of the thoracic duct.—The thoracic duct is not often seen during these operations. A sudden welling-up of clear or milky opalescent fluid into the wound will occur if the duct has been divided—not a very infrequent accident, though fraught with no untoward results, owing to the number and freedom of the anastomotic channels. The ends of the duct should be picked up with pressure forceps and ligatured ; when this is impossible, it may be necessary to pack the wound with gauze for a few days. The great majority of cases of wounds of the thoracic duct end in recovery (*see* also p. 1738).

Complications.—The degree of general reaction following operations on the cervical nodes varies considerably. As a rule it is slight, depending on the amount of trauma at the operation. There may be a rise of temperature with signs of severe general intoxication, from which the patient recovers, but fatal cases of generalized tuberculosis have been recorded. Such accidents are avoided by operating only where surgical interference is justified after careful local and general examination, by doing the minimum amount of damage during the operation (cutting rather than tearing), and by draining the wound.

Hæmatoma.—The bleeding is usually venous in origin, and easily controlled by firm pressure with the bandage, over pads of wood wool. Care must be taken to secure all vessels, particularly those in the lower part of the parotid, and, if in doubt about possible oozing, to drain the wound. If the wound is at all tense, the hæmatoma should be evacuated with sinus-forceps and a small drain inserted.

Exudation from divided lymph-vessels.—A certain amount of swelling is not uncommon, due to an escape of lymph from the divided lymph-channels.

In the supraclavicular region there may be an external lymphatic fistula following the division of large vessels such as the thoracic duct. With firm pressure, this usually ceases in a few days ; if not, the lower part of the wound should be packed with sterile gauze. In rare cases it may be necessary to explore the wound and secure the oozing vessels.

Paresis of the lower lip.—Immediately after operation there may be some weakness of the lower lip, due to paralysis of the depressor labii inferioris and division of the platysma. This usually disappears in a few weeks, but may be permanent. The lesion is due to injury of the cervical branch of the facial nerve, before it gives off the fibres which unite with the mandibular nerve to supply the depressor labii inferioris.

Division of the spinal accessory nerve.—If this nerve is inadvertently divided during the operation, it should at once be sutured with the finest catgut or silk.

The degree of disability resulting from division of the spinal accessory varies very much. If divided before entering the sterno-mastoid, that muscle is partly paralysed and atrophies, but movements of the head are not impaired, and there is no wryneck. Division in the posterior triangle usually causes a partial paralysis of the trapezius, but no obvious disability.

Division of the muscular branches of the 3rd and 4th cervical nerves with the spinal accessory leads to complete paralysis of the trapezius with atrophy. The shoulder on the affected side droops, the inferior angle of the scapula becomes prominent and rotated towards the spine.

Division of the hypoglossal nerve leads to atrophy of the corresponding half of the tongue, which is protruded towards the injured side. The nerve is most liable to damage from the point at which it hooks round the occipital artery to that at which it disappears under the posterior belly of the digastric. On the hyoglossus the nerve is covered by fascia, and in front of this muscle it lies deep to the mylohyoid muscle. It is wonderful how soon the resulting disability is compensated.

Injury to the phrenic nerve.—Stimulation of the phrenic nerve causes spasm of the diaphragm of the same side, and division of the nerve leads to paralysis of the corresponding side of the diaphragm. Theoretically, division of the nerve may cause sudden death by embarrassing respiration, but this risk, like the danger of division of the thoracic duct, has been exaggerated.

Thin stretched scars result from sepsis, from neglect to suture the platysma and deep fascia, and from incisions at right angles to the lines of tension in the neck. **Cheloid scars** may result from sepsis or a chronic tuberculous infection of the scar. Depressed scars may be raised by grafting autogenous flaps of fat, and radium emanations or X-rays will sometimes cure painful or cheloid scars.

TREATMENT OF TUBERCULOUS ABSCESSES IN THE NECK

The surgeon must remember that, in the majority of cases, beneath the deep fascia and muscles there are infected nodes which may be attached to important structures and which can only be dealt with by excision. From this it follows that procedures such as aspiration or incision and curettage have a very limited application in ordinary practice, although they may be usefully employed in institutions devoted to the conservative treatment of surgical tuberculosis. Such procedures must only be undertaken with the strictest aseptic precautions.

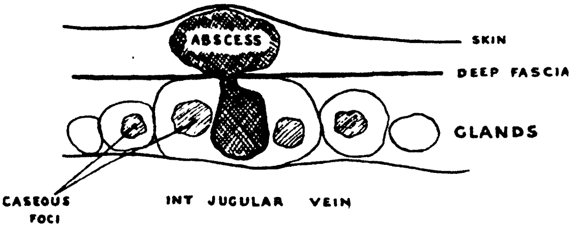

Fig. 836.—Diagram of subcutaneous abscess with deep caseating foci.
Reproduced by permission of F. C. Pybus.

A chronic abscess, not involving the skin and obviously fluctuating, which is frequently the result of tonsillar infection, may be aspirated. The needle attached to the syringe is pushed obliquely through healthy skin from above downwards into the upper part of the abscess cavity. A little 2 per cent. iodine or 2 per cent. solution of gentian violet in water is injected into the cavity. The procedure may have to be repeated several times at weekly intervals. It is important to have the needle puncture in the upper part of the abscess. If it is placed in the dependent part of the abscess, leakage by gravity will increase the risk of infecting the needle track.

A subcutaneous abscess with a fixed mass of nodes under the deep fascia may be incised and curetted. (Fig. 836.) After the contents are evacuated, the hole in the deep fascia is found and the caseous node just beneath the fascia is gently curetted away. The cavity is lightly packed with gauze soaked in 6 per cent. iodine for a few minutes. The gauze is removed, taking care that the strong iodine does not come in contact with the skin, and the wound is sutured. If the deeper nodes persist after the abscess is soundly healed, it may be necessary to excise them by a properly planned operation.

Mortality.—By choosing suitable cases and applying to them the appropriate technique, the risk of operations on the cervical nodes is negligible. Including anæsthetic and so-called status-lymphaticus deaths, the mortality is not greater than that of operations for the radical cure of reducible hernias. But each case must be considered on its merits, disregarding statistics, because there is always the risk of lighting up generalized tuberculosis, or of stirring an old focus into activity, in all cases where the disease is not primary in and localized to the neck.

In 1,300 cases collected from the literature, there were two deaths—apparently due to an acute toxæmia—immediately following operation, and one four weeks after operation, from generalized tuberculosis.

End Results.—With more radical methods of operating, the liability to local recurrence in the neck has been diminished from 30 per cent. to less than 8 per cent. In the older statistics the development of tuberculosis elsewhere following operations on the cervical nodes was not less than 40 per cent., and equal to that in cases not dealt with operatively. The later statistics of radical operations are much more favourable, not more than 5 per cent. of the cases subsequently developing phthisis or bone-and-joint tuberculosis.

At the Medical Society of London in February, 1922, Grey Turner[*] gave the after-history (5–18 years) in 83 cases of operation for tuberculous cervical nodes. The results were : Perfectly well, 54 ; good health, but small nodes near operated area, 15 ; alive, but other groups of nodes involved, 4 ; alive, but with other tuberculous manifestations, 2 ; died of tuberculous disease, 6 ; died from other causes, 2. Of 63 cases belonging to the naso-pharyngeal group, 60 were perfectly well or greatly improved. Of 20 cases belonging to the mesenteric group, only 9 were perfectly well or greatly improved. These figures show that the prospects of cure are best in cases where the enlargement is secondary to infection from the mouth and throat. The prognosis after removal of cervical nodes which are secondary to mesenteric infection is not so good, but the removal of the nodes before they have broken down and involved the skin may be a valuable adjunct to general treatment.

The results of operative treatment are worst in cases secondary to mediastinal and lung infections. Such cases of infection of the supraclavicular glands are usually seen in adults (senile tuberculosis), and operation is rarely justifiable. In the naso-pharyngeal group, early removal of the nodes before the disease has spread beyond the neck diminishes the liability to bone- or joint-tuberculosis later in life.

Brian C. Thompson,[†] Assistant Tuberculosis Officer for the County of Durham, gives his experience of 195 patients with tuberculous cervical nodes which he observed in 1934. He found that surgical

[*] *Brit. Med. Journ.*, 1922, i, 352.
[†] *Lancet*, 1936, i, 946.

excision gave very bad results. In 70 per cent. the disease recurred, and in nearly half of the remaining 30 per cent. there was persistent sinus formation. In the more chronic types which were aspirated, 87.5 per cent. developed sinuses. Incision or incision with curetting was performed in 70 patients and this is the surgical procedure most favoured by him. He concludes that surgical treatment is unjustified and is not to be recommended. This is much too gloomy a picture of the results of surgery. Nearer the truth are the results published by Barrington Ward.* He gives the results of a consecutive list of 133 complete operations in children up to the age of 12. Of these 95 were traced and 89 were personally examined. There was no operative mortality, only one required further treatment and all were in perfect health. My own series of 171 patients includes children, adolescents and adults. In 97, abscesses were opened and curetted; in eight sinuses were scraped and in 66 the glands were excised. There were no deaths resulting from operation. The results favour complete excision of the whole of the affected area. Sinuses should be excised *en bloc* with the nodes beneath the deep fascia. Abscesses should be excised by dissection before the skin becomes involved.

TREATMENT OF RETROPHARYNGEAL ABSCESSES

There are three types of retropharyngeal abscess :—

1. *Secondary to tuberculous disease of the spine.*—These are usually median in position, and spread through the prevertebral fascia, lying behind the constrictor muscles of the pharynx and bucco-pharyngeal aponeurosis. As the abscess increases in size, it pushes the posterior wall of the pharynx forward and may point there; or it passes behind the prevertebral layer of the deep cervical fascia and the carotid sheath to point at the posterior border of the sterno-mastoid muscle; or in front of the pervertebral fascia to point at the anterior border of the sterno-mastoid muscle.

Such abscesses must never be opened through the pharyngeal wall. An incision is made at the anterior or posterior border of the sterno-mastoid, and the carotid sheath is displaced forward. A pair of sinus-forceps is passed behind the carotid sheath into the abscess cavity. The opening is enlarged with the forceps, and the wall of the abscess cavity is gently curetted with a sharp spoon or flushing curette. The cavity is dried with spirit, wiped out with gauze, saturated with 6 per cent. iodine, and the wound in the neck is closed without drainage. If the skin is already involved, the saturated gauze may be left in the cavity for forty-eight hours and then removed.

2. *Arising in the retropharyngeal lymphatics and nodes secondarily to infection spreading from the pharynx or deep cervical glands.*—Such abscesses are lateral, and at first lie behind the constrictor muscles and bucco-pharyngeal aponeurosis. They should be opened by an incision in the neck, unless they are actually pointing in the pharyngeal wall.

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* *Lancet*, 1937, i, 980.

3. *Arising in the pharyngeal wall behind the mucous membrane secondarily to septic adenoids or tonsils.*—These abscesses may be median or lateral, and are of similar pathology to a quinsy or peritonsillar abscess. They are drained through an incision in the pharyngeal wall under light general anæsthesia.

The patient lies in the dorsal recumbent position with the head extended over the end of the table or on one side. The mouth is held open with a gag and the tongue held forwards with forceps and well depressed with a spatula so that the surgeon can see what he is doing. A vertical incision is made into the whole length of the abscess from below upwards with a knife guided by the index finger of the left hand. The pus which collects in the naso-pharynx is mopped up with sponges on holders, and all loculi in the abscess cavity are broken down with the finger. The throat is sprayed with antiseptic for a few days, until the incision has healed. The primary cause of the abscess must be dealt with later.

REMOVAL OF SECONDARY MALIGNANT LYMPH NODES FROM THE NECK

The technique of all operations on the neck should generally be similar to that described in connexion with tuberculous nodes. But in the presence of malignant disease the dissection must be strictly *en bloc* and no attempt must be made to spare invaded structures. As a rule, the carotid sheath must be taken away and the spinal accessory nerve divided. In the rest of this article, reference will be made only to special features, where the pathology of the disease alters the scope of the operation but not the technical details.

Spread of malignant disease from the primary focus to the nodes in the neck.—The *permeation* theory of cancerous metastasis has led to the principle of removing the primary growth with a margin of healthy tissue beyond the possible area of local infection of the lymphatic plexuses in and around the tumour, together with the lymphatic vessels and nodes, all in one piece. The application of such a principle to all growths which give rise to secondary deposits in the neck would lead to a great increase in the mortality of these operations, and therefore, as a routine method, would only be justifiable if a better immediate and remote prognosis could be assured. If a free communication is made between the floor of the mouth or the pharynx and the cellular tissues of the neck, there is a great risk of an increased mortality from infection of the neck wound and spreading cellulitis.

Many patients, even with comparatively early growths, could not bear such an extensive operation because of their poor general condition, for arterio-sclerosis, albuminuria, glycosuria and bronchitis are the rule rather than the exception in such cases.

There is no doubt that permeation is much more rapid on mucous surfaces, such as the floor of the mouth, the inner surface of the cheek, the faucial pillars, the pharynx and posterior third of the tongue, than it is on the anterior two-thirds of the tongue or the outer surface of the lips.

In cancer of the tongue, Butlin's results show that the tissue intervening between the tongue and the nodes is rarely the seat of recurrence. The recurrences are met with in the nodes and deeper parts of the tongue, and are therefore due to incomplete removal of the nodes or, as Cheatle[*] has pointed out, to leaving the deeper muscles of the tongue. Dudgeon and Mitchiner[†] have shown by microscopical examination of the sublingual and submaxillary salivary glands in early and late cases of carcinoma of the tongue, lip, and floor of the mouth, that secondary deposits in these salivary glands are very rare. The deposits are confined to the lymphatic nodes which are in intimate relation with the submaxillary salivary gland. The changes in the submaxillary salivary gland which cause it to become enlarged and hard, or merely hard—the condition regarded as clinical evidence of malignancy—are due to spread of inflammation from the mouth. It seems clear, therefore, that in cancer of the tongue there is a local permeation of the lymphatic plexuses in the tongue, but the larger vessels running from the tongue to the lymphatic nodes are not permeated until very late in the disease. From this it follows that the early glandular invasion is the result of lymphatic *embolism.* The cancer-cells lodge in the nodes by passing along the lymphatic vessels, the latter being free from growth. If the larger vessels running from the tongue to the nodes are not permeated until late in the disease, an operation in one, two, or three stages, leaving behind the tissues between the tongue and the nodes, is pathologically sound, and justifies the clinical faith in it. Thus, in a number of cases it will be possible to diminish the danger of operation by avoiding a communication between the floor of the mouth and the neck without increasing the risk of subsequent recurrence. It is equally obvious that in many other cases of cancer of the tongue and other parts of the mouth, fauces, tonsils, and pharynx, a free communication must be made between mucous surfaces and the cellular tissues of the neck to get proper access to, or to secure wide removal of, the primary growth.

Since the secondary deposits spread to the nodes by embolism, a more rapid process than permeation, it follows that, however small the primary growth may be, a block dissection of the nodes which from the anatomical position of the growth may be expected to become infiltrated must be undertaken in every case. If the primary lymph-nodes are obviously diseased, permeation may have taken place along the smaller interglandular lymphatics ; and even before the nodes are macroscopically diseased, embolic spread to more distant glands may have begun. From the pathological point of view, a radical operation on the secondary nodes must be nothing less than the removal *en bloc* of the submental, submaxillary, upper deep cervical, and lower deep cervical nodes on one or both sides of the neck. The clinical fact that the patients usually die before the glandular metastases have spread beyond the neck is in favour of these extensive neck dissections. A palliative operation on the neck is justifiable if there is a prospect of saving the patient from the discomfort and misery of a foul-smelling fistula due to broken-down malignant disease.

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[*] *Pract.*, 1905, lxxv, No. 5, 623.

[†] *Lancet*, 1922, ii, 558.

The operation of removing all the nodes *en bloc,* though ideal pathologically, cannot always be carried out with advantage to the patient or to the surgeon. When a patient is a good surgical risk and consents to a two- or three-stage operation, it should be done.

In early cases, before the nodes are obviously diseased, the surgeon may feel that such an extensive operation is unnecessary, and may confine his dissection to the removal of the primary lymph-nodes and the deep fascia, with ultimate good result. In more extensive cases, where a bilateral node dissection is called for, the patient may be unwilling to submit to a three- or even a two-stage operation. Many patients would be precluded altogether from an operation on the nodes on account of their poor vitality, if removal in three or two stages became the minimum standard of operative procedure. Experience justifies less radical operations which pathologically are merely palliative.

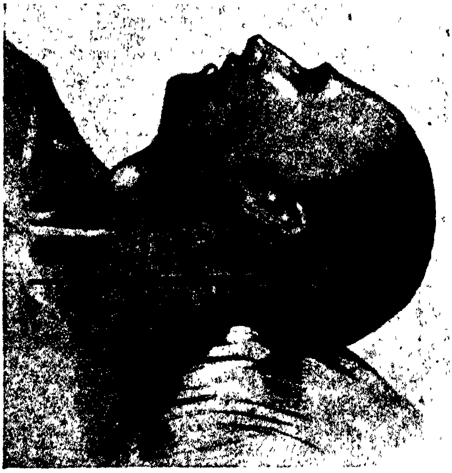

Fig. 837.—The standard incision for thorough clearance of the neck in malignant disease.

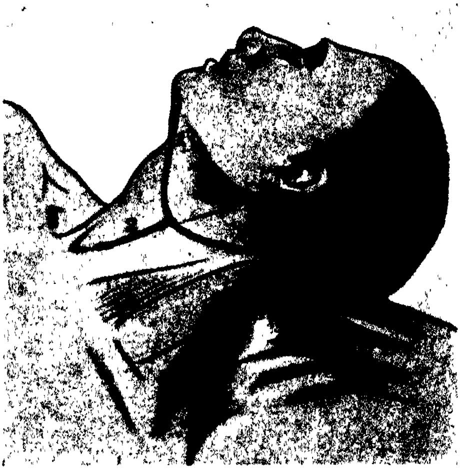

Fig. 838.—Incision for more limited removal of malignant glands.

Block dissection of the lymphatic system of the neck (Crile's method) is carried out, when required, on the same lines as the Halsted operation for cancer of the breast. The lymphatic system should be excised one month after the primary growth has been irradiated or removed.

The incisions shown in Fig. 837 are made and the skin is reflected over the entire area of the field. The sterno-mastoid is divided at its attachments and removed. The internal and external jugular veins are secured and divided between ligatures at the base of the neck. The dissection is then carried from below upward into the deep plane of the neck; working first at the sides and then posteriorly, carrying upward all the fascia, muscles, veins, fat and connective tissue. The upper end of the internal jugular vein is ligatured. Where no temporary clamp is placed on the common carotid artery, some surgeons prefer to tie the upper end of the internal jugular first, so that dissection is not hindered by the distended vein.

Only one side of the neck should be operated upon at one time. If the other side has to be done later, the internal jugular vein must not be removed.

A drain is put in the lower angle of the wound. For some time after the operation there is œdema of the lower part of the face. There is also a temporary lower facial palsy.

RADIUM IN THE TREATMENT OF THE NECK LYMPHATICS

Some surgeons believe that, even after satisfactory removal of the node-bearing areas, it is well to use external radiation as a measure of prophylaxis. This should not be undertaken until the incisions are soundly healed, and seldom sooner than a month after operation. The radium is then applied on a Columbia paste collar.

When malignant nodes are fixed in the neck the growth may have invaded the tissues beyond their capsules. In these circumstances operation is not likely to be successful, and radium probably holds out better prospect. Such a condition calls for interstitial radiation either through puncture of the unbroken skin or, better, under the guidance of the eye after exposure by open incisions. In some cases where operation is undertaken, the surgeon may find so much infiltration that the nodes cannot be removed, or at least not with a margin of healthy tissue. When this is likely, radium should be in readiness and should be implanted into and around the area after as much of the glandular mass as possible has been removed.

THE SURGERY OF THE THORACIC DUCT

The thoracic duct is the connecting link between the small intestine and the venous system. It ascends through the superior mediastinum into the neck. At the level of the sixth cervical vertebra it arches outwards and forwards above the pleural sac and the first part of the subclavian artery. (Fig. 835.) The danger of wounding the duct is increased by the fact that its arch may be over two inches above the upper border of the sternum and touching the thyroid gland. The duct passes in front of the vertebral artery and vein, the roots of the inferior thyroid, transverse cervical and suprascapular arteries, the inner border of the scalenus anticus muscle and the phrenic nerve. It passes behind the carotid sheath and its contents and joins the commencement of the left innominate vein. Shortly before its termination it receives the lymph-ducts coming from the left side of the head and neck, from the left arm and the left mamma. A pair of valves, formed of semilunar folds of the inner coat, is situated at the orifice of communication with the innominate vein. Sometimes the duct divides, one branch emptying into the right subclavian vein. It may end in the left internal jugular, vertebral or subclavian veins ; and very rarely in the vena azygos major. The outlet of the duct may be double, and sometimes there are several openings into the vein, forming a delta. This explains why injury to one branch causes no serious harm if the damaged branch is ligatured. There are often anastomoses with the azygos vein in the chest and with the duct on the right side and therefore it is easy to understand why simple ligature of the main duct when it has been wounded produces no harmful result.

WOUNDS OF THE THORACIC DUCT

Injury to the thoracic duct is an occasional complication of operations on the left side of the neck. The immediate result is usually a sudden welling-up of clear or milky opalescent fluid into the wound, but frequently the chylorrhœa has not developed for some hours or even days after the operation. In these cases probably the wound has been a slit which has been closed temporarily by blood clot. The amount of chyle which escapes may be enormous. Thoele describes a case in which the patient was literally deluged. The condition which may develop has been observed and described many times. The patient complains of hunger and appalling thirst. Ingestion of food is followed by a marked increase of the discharge of chyle from the wound. This is followed by emaciation and progressive loss of strength, weakness of the pulse, and finally loss of consciousness. There is some fever, probably due to absorption of nucleins and albumens. Despite this serious sequence patients usually make a slow recovery, due to the gradual closure of the fistula and the dilatation of the anastomotic channels between the ducts of the two sides and the communications in the thorax.

Treatment.—Ample clinical experience has shown that the best plan is to apply a ligature, as with a divided or torn vessel. Fine chromic catgut should be used, as plain catgut may absorb too quickly, and leakage may result. Gauze packing must be used when the point of injury cannot be controlled by ligature, the wound being firmly packed with dry ribbon gauze. Only small quantities of fatty food are allowed, until the collateral circulation is established. Thirst is allayed by continuous saline infusion into the right arm or right side of the chest wall. The gauze is not touched until the fourth day when it is merely loosened, removal being completed at the end of a week.

Other methods, such as suture of the duct or its implantation into a neighbouring vein, are unnecessary and are now of academic interest only.

Sometimes leakage from the thoracic duct is not observed at the time of operation but the escape of chyle from the wound may be noticed some days later, or after the wound has healed there may be a considerable collection of fluid which on relief is found to be milky. Such a secondary fistula will usually close spontaneously if drainage on to the surface is free and if pressure is carefully applied to keep the tissues in contact. If healing does not occur, the incision should be re-opened and the leaking area tamponnaded with gauze soaked in tincture of iodine to set up reaction. Secondary ligature of the duct has occasionally been necessary, but should not be attempted in the first instance because of the disturbance of the parts necessary to expose the actual leaking point.

Drainage of the Thoracic Duct.—Lymphaticostomy

Drainage of the thoracic duct in severe cases of peritonitis was introduced by Costain* in 1922. At the present time it is not possible to assess the value of lymphaticostomy on a clinical basis. Further, the experimental evidence is conflicting and Paterson Brown† concludes that lymphaticostomy cannot be recommended as holding out any hope to patients suffering from acute peritonitis.

Recovery after lymphaticostomy has been recorded in pneumococcic peritonitis, puerperal peritonitis, perforated appendicitis with and without removal of the appendix, and perforated duodenal ulcer, but what part it played in the survival of the patients is not clear. Wilms drained the duct for fat embolism in a man of twenty who fell from a second story window. The duct drained freely for thirty-six hours and in the first twenty hours two quarts of chyle escaped. The vessel closed in six days and the patient recovered.

Technique.—A three-inch incision is made through the skin over the lower posterior border of the left sterno-mastoid muscle. The muscle is freed by blunt dissection and drawn inwards, exposing the omo-hyoid muscle, which is drawn up. The internal jugular vein, thus exposed, is liberated down to the junction with the subclavian vein and rolled inwards and the thoracic duct, about the size of a goose quill, is brought into view. The duct is freed for about one inch and a ligature of plain catgut is tied around it close to its entry into the innominate vein. A half-inch longitudinal incision is made into the lumen of the duct a little distance from the ligature on its proximal side, thus allowing the chyle to escape. Swabs of this fluid should be taken for bacteriological examination. A narrow strand of rubber is passed about half an inch into the duct. A single strand of plain selvedged gauze is loosely tucked around the duct. The rubber strand, the gauze and one end of the ligature round the duct are brought to the surface and secured to the skin. The skin incision is then closed around a quarter-inch soft rubber tube, and a moist dressing applied. Costain emphasizes the importance of blunt dissection which makes almost a bloodless operation. After the operation abundant fluids must be given, especially by the mouth, in order to secure a continuous flow of lymph. In Costain's first patient with pneumococcic peritonitis there was a free drainage of lymph on the first and second days. The drainage was slight on the fourth day and ceased on the eighth day. Bailey and Love* state that the duct may be more readily identified if the patient is given a good drink of cream about an hour before the exposure.

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* *Canadian A.M.J.*, 1922, N.S. xii, 789, and *Surg. Gyn. & Obst.*, 1923, xxxvi, 365

† *Brit. Journ. Surg.*, 1928, xv, 538.

TREATMENT OF OTHER CERVICAL GROWTHS

Lympho-sarcoma, branchiogenetic carcinoma, and lymphadenomatous growths.—When primary in the neck, lympho-sarcoma remains localized for a considerable time, and the patients usually die from cachexia before extensive metastases have formed. Removal of such growths in their early stages, followed by large doses of X-rays or radium, or the use of Coley's fluid, is well worth undertaking. Lympho-sarcoma, branchiogenetic carcinoma, and lymphadenomatous tumours are best excised by block dissection through an ample incision over the sterno-mastoid muscle, which is removed together with the nodes and fascia. (Fig. 837.)

Lymphangiomatous tumours, hæmangiomata, blood-cysts, or cystic hygroma.—These growths occur as congenital cystic swellings containing yellow, green, or brown fluid, or blood, and are usually multilocular. Operative treatment is indicated when the cysts are increasing in size or producing symptoms such as dyspnœa or difficulty in swallowing. Owing to their connection with the lymphatic system, the cysts may extend into the intermuscular planes and the muscles, so that complete removal by dissection without damage to important structures is impossible.

When excision must be undertaken, the main group of cysts is removed by dissection and the wound wiped out with 6 per cent. iodine to obliterate by cicatrization the deeper parts lined with endothelium. The iodine must not be allowed to come in contact with the skin.

Thyro-glossal cysts and fistulæ and accessory thyroids are considered on p. 1747.

Tumours of the carotid body.—These are situated in the middle of or just deep to the bifurcation of the common carotid artery, in close relation with the hypoglossal and vagus nerves and the sympathetic chain. The majority of the tumours are innocent, and even the malignant ones do not give rise to metastases. They usually exhibit transmitted pulsation but occasionally they lie deep and push the vessels forward. They are movable laterally but not vertically. They should be approached by an ample incision along the anterior border of the sterno-mastoid muscle. The internal jugular vein is divided between ligatures below the tumour and dissected upward. It is usually necessary to ligature or excise a portion of the external carotid artery in order to remove the tumour completely.

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* A Short Practice of Surgery, 1935.

In some cases the tumour cannot be removed without resection of both the internal and common carotid arteries. In such cases it should be left until a biopsy proves it to be malignant. Division of the hypoglossal nerve may be unavoidable. When practicable, the vagus should be dissected from the tumour but both it and the sympathetic may have to be divided and a part removed. If the sympathetic is resected with the tumour, slight miosis and enophthalmos will ensue.

Branchial cysts, dermoids and fistulæ arise in the neck from persistence of the whole or part of the branchial clefts.

Cervical sinus, or branchial fistula, is due to persistence of the whole or part of the second branchial cleft, so that the track passes between the internal and external carotid arteries in intimate relation with the superior laryngeal nerve, and ends in the pharynx at the fossa of Rosenmüller. The cyst is dissected away through a transverse incision over the swelling. It is essential to remove every bit of the wall. Some surgeons deliberately open very large cysts and insert a finger as a guide to the dissection of their deepest part. To facilitate removal the area may be injected with 2 per cent. gentian violet solution in water.

The sinuses are treated in three ways: (1) The track is dissected out completely through an incision which encircles the sinus. (2) The lower part of the track is dissected away and twisted off from its deeper connection to the pharynx. (3) In the very rare cases where the connection with the pharynx is patent, the greater part of the sinus is dissected free, a probe is passed through into the pharynx, and the remainder of the sinus is secured to the probe with a ligature. The probe is then withdrawn from the pharynx. The sinus is thus turned inside out and may be cut off from its attachment to the pharynx.

Sequestration dermoids, sebaceous cysts, and lipomata are removed through incisions in or parallel with the creases in the skin. Encapsuled lipomata shell out easily through a comparatively small incision. Diffuse lipomata, which usually occur on the back of the neck, demand free incisions for their removal.

Cervical auricles.—These are generally represented by remnants of cartilage buried in the superficial tissues. Removal is not difficult, but the necessary incisions should be made obliquely in the natural folds.

Abscesses, even though acute, should be opened by oblique incisions following natural folds, as the resulting scars are then much less conspicuous.

Ludwig's angina may be regarded as an exception, for this is often so serious and acute that cosmetic considerations have to be disregarded. A deep incision over the centre of a line from the symphysis to the body of the hyoid is essential.

Operations on the vessels and nerves of the neck will be found on pp. 471 and 502 of Vol. I.

CHAPTER XXXVIII

OPERATIONS ON THE THYROID GLAND

By SIR JAMES WALTON

ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

THE thyroid body is a gland of internal secretion which partly envelops the upper portion of the trachea. It varies in size, being generally larger in the female than in the male and in the former sex increases in size during menstruation and pregnancy. It consists of two lateral lobes placed on either side of the trachea, united in front by the isthmus. The lateral lobes are pyramidal with the base downward, the apex extending up to a position varying from the lower border to the middle of the ala of the thyroid cartilage and the base reaching as low as the 6th tracheal ring. The isthmus is a narrow band running across the 2nd, 3rd and 4th tracheal rings. Generally, from its upper border there passes a narrow prolongation, the pyramidal or middle lobe, which may reach as high as the hyoid bone and lies in front of the thyroid cartilage. (Fig. 839.) In front the gland is covered by a sheet of muscle formed by the sterno-thyroids, the sterno-hyoids and the anterior bellies of the omohyoids, only a small portion of the isthmus being left uncovered in the mid-line. Superficially, it is covered in front by the platsyma and the anterior

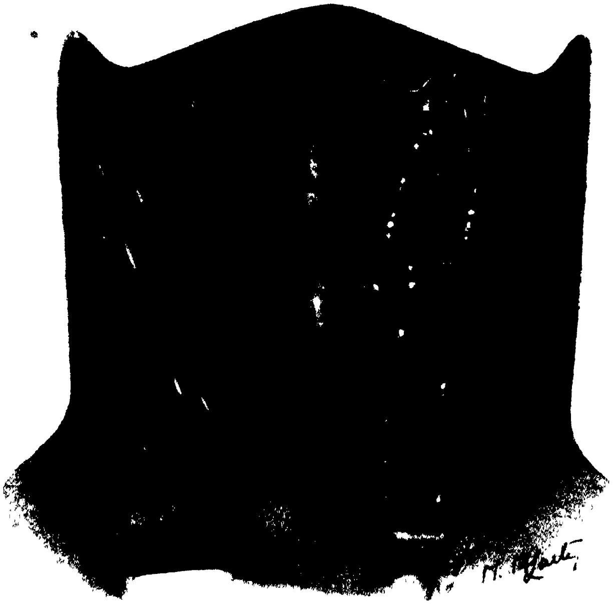

Fig. 839.—The thyroid seen from the front.

jugular veins and laterally by the converging sterno-mastoid muscles; behind it embraces the trachea, but the posterior surfaces of the lateral lobes form grooves in which the carotid sheath lies. (Fig. 840.) The portion between the carotid artery and the trachea passes deeply to be in relation with the longus colli muscle and on the left side with the œsophagus. On the inner side of this portion lies the recurrent laryngeal nerve which, as it passes beneath the inferior constrictor, lies internal to the lateral lobe. Internal to the apex is the external laryngeal nerve, lying on the inferior constrictor before entering the crico-thyroid muscle.

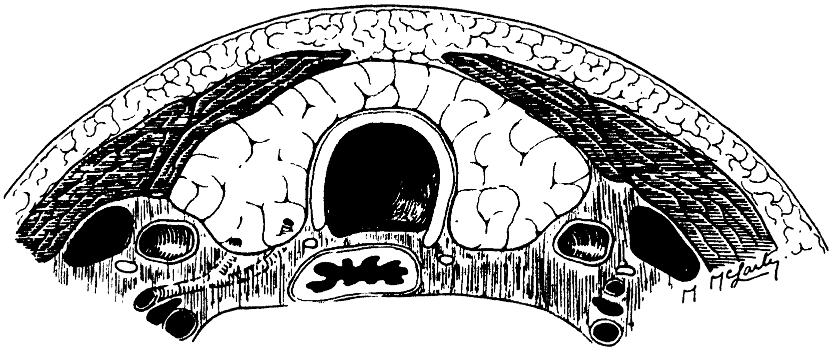

Fig. 840.—Transverse section of the thyroid gland.

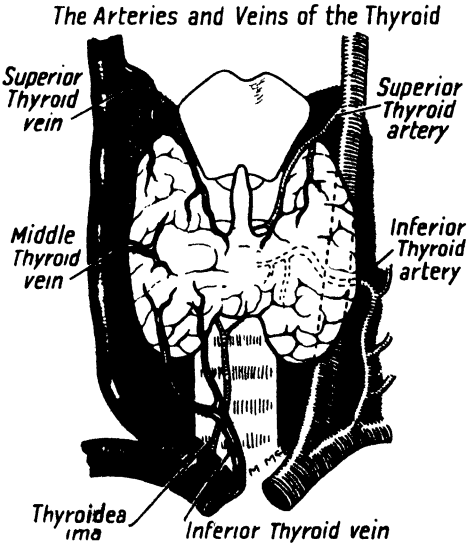

Fig. 841.—Vessels of the thyroid.

Vessels.—The gland is very vascular. (Fig. 841.) On each side the superior thyroid artery passes downward from the external carotid to reach the apex, where it divides into three branches, one of which passes across the upper border of the isthmus to anastomose with its fellow; the others pass along the anterior and posterior surfaces of the lateral lobe. Above them the sterno-mastoid branch passes along the upper border of the anterior belly of the omohyoid. A branch may enter the pyramidal lobe directly from the main trunk or from the crico-thyroid branch. The corresponding veins pass upward with the artery to enter the internal jugular vein. The inferior thyroid artery arises on each side from the thyroid axis under cover of the internal jugular vein; passing upward along the inner border of the scalenus anticus muscle it turns inward at the level of the cricoid cartilage lying on the longus colli muscle and deep to the carotid sheath. It divides into two or more branches which enter the postero-internal surface of the lateral lobe. In its terminal part the recurrent laryngeal nerve may lie in front of, behind, or between its two terminal branches. A branch from the innominate artery, the thyroidea ima, may pass upward to enter the lower border of the isthmus. The middle thyroid veins are variable and may be absent. They arise from the anterior surfaces of the lateral lobes and pass outward to join the internal jugulars. The inferior thyroid vein is said to arise on either side, to pass downward, to unite with its fellow and enter the left innominate vein; more commonly there is a plexus of several veins on either side, the branches of which pass down to enter both innominate veins. (Fig. 842.)

Fig. 842.—The deep relationships of the thyroid.

Lymphatics.—The gland has a free lymphatic supply, large trunks passing out to form plexuses beneath the capsule from which run vessels to enter the deep cervical glands.

Fascia.—The fascial relations of the thyroid are somewhat complicated but of practical importance (*see* Fig. 843). The sternomastoid muscle is enclosed in a sheath; the inner layer of this splits to enclose the carotid vessels (the carotid sheath) from the inner layer of which pass two septa, the deep, prevertebral or thyroid fascia passing behind the thyroid, trachea, and œsophagus to join its fellow on the opposite side, and the superficial or pretracheal fascia passing in front of the thyroid deep to the pretracheal muscles. These two layers pass downward, the pretracheal to fuse with the pericardium, and the prevertebral to fade away on the longus colli. Hence there is a free passage into the thorax both in the thyroid compartment and behind the prevertebral fascia. In addition there is a well-defined capsule to the gland.

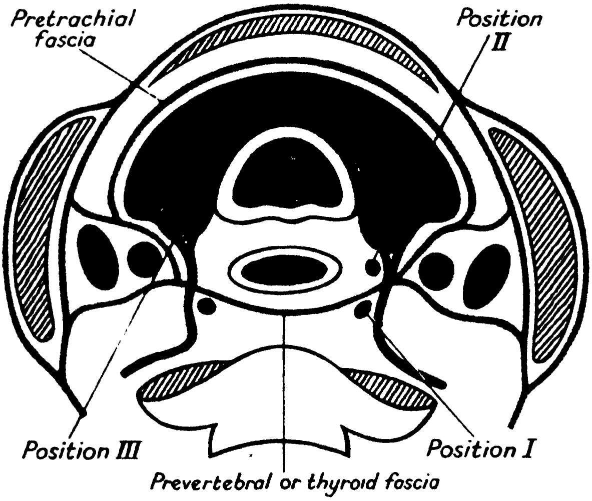

Fig. 843.—The fascial relations of the thyroid and parathyroids.

Accessory thyroids.—The thyroid gland is probably developed in three portions. The central part arises as a downgrowth from the ventral wall of the pharynx at the junction between the basal portion of the tongue and the tuberculum impar, the upper portion of this diverticulum being represented in the adult by the foramen cæcum. The diverticulum grows downward in front of the larynx, bifurcates at its lower end and, lying in front of the upper part of the trachea, forms the isthmus of the thyroid. The rest of the diverticulum persists above as the foramen cæcum and in its lower part forms the pyramidal lobe. The portion between should disappear but may persist, especially in its lower part, as the thyro-glossal duct. Portions of thyroid tissue may develop in any part of its course and may form accessory thyroids. These may be situated in the tongue, near or deep to the foramen cæcum (lingual thyroids), and sometimes may be the only thyroid tissue present. In other cases the lateral lobes may be normal but the isthmus may be absent. The lateral lobes are formed independently, from downgrowths on each side from the fourth visceral cleft. They grow down by the side of the larynx, become shut off from the cavity of the pharynx and, joining the isthmus, form the lateral lobes. Small portions may become detached to form accessory thyroids, which are usually placed on the lateral aspects of the lateral lobes, but may be formed below them and even in the superior mediastinum.

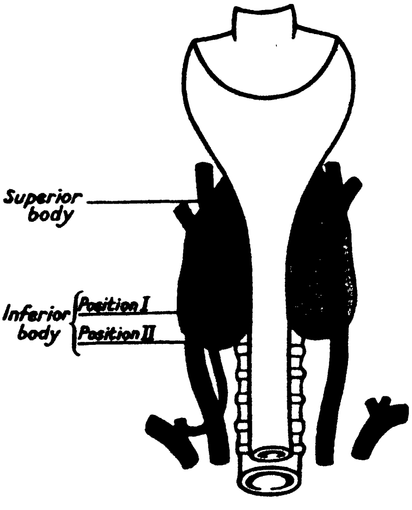

Fig. 844.—The usual position of the parathyroids as seen from behind.

The **parathyroid bodies** are minute yellowish glands lying in close relationship with the thyroid. Variable in number, there is usually a superior and inferior body on each side. They are also very variable in position, but generally lie in relation to a wide strip on the posterior aspect of the lateral lobe of the thyroid gland, extending from the upper to the lower poles. The superior are more constantly situated on the posterior surface of the upper pole, but may be placed relatively far forward, in which case they may be accidentally removed during the operation of partial thyroidectomy. Their blood supply comes from branches of the superior thyroid artery. Whereas the superior bodies are developed from the 4th branchial pouch and pass inward behind the common carotid artery, the inferior develop from the 3rd pouch and pass downward with the thymus gland, between the common carotid artery and internal jugular vein, and thus, as Gordon-Taylor has shown, might lie anywhere along a line joining the greater cornu of the hyoid bone to the pericardium. Most frequently they are placed on the posterior surface, either just above or below the inferior thyroid artery as it enters the thyroid capsule. Not infrequently they may lie below the pole in relation to the inferior thyroid vein. Occasionally they may be placed inside the thorax in relation to the thymus gland, a position of importance if they are the seat of tumours. Their blood supply comes from branches of the inferior thyroid artery. Either body, but more commonly the inferior, may be placed within the substance of the thyroid gland. (Fig. 844).

A very important relationship is that to the prevertebral or thyroid fascia. The superior bodies always appear to be superficial to, that is, in front of, the fascia. The inferior, however, if placed above the inferior thyroid artery, appear to lie behind the fascia. A tumour of this gland, therefore, if displaced downward, would pass behind the œsophagus to lie in front of the upper dorsal vertebræ. (Figs. 843 and 859.) If, however, placed below the artery, they lie generally in front of the fascia, and therefore if displaced downwards come to lie behind the sternum in a similar position to a retrosternal goitre.* Not infrequently there are four or more bodies on either side.

Function.—The thyroid gland controls the iodine metabolism of the body. If hypertrophied and overactive, it causes an increased metabolism with all the symptoms of exophthalmic goitre. If absent or atrophic at birth, it causes cretinism with decreased metabolism, while a similar lack of function after development causes myxœdema. In many cases an enlargement or goitre appears to depend on an actual or relative iodine insufficiency, and it then seems as though the gland were attempting to overcome the deficiency in the quality of its secretion by forming an increased quantity.

The parathyroid glands control the calcium metabolism. The removal of the parathyroids or a decrease of their function is followed by a reduction of the serum-calcium and a decreased calcium secretion, which is followed by the symptoms of tetany. Over-action of the parathyroid glands from hypertrophy or tumour formation, on the other hand, gives rise to an increase of blood-calcium and calcium excretion, with a fall in the blood-phosphorus but an increase in its excretion. The increased amount of calcium is derived from the bones, and its extraction causes profound changes in these structures, the so-called generalized osteitis fibrosa. The excretion of such increased amounts of calcium salts may cause the formation of renal calculi.

CONGENITAL ABNORMALITIES

THYRO-GLOSSAL CYSTS AND FISTULÆ AND ACCESSORY THYROIDS

Indications for operation.—Normally the thyro-glossal duct should disappear entirely, but portions of it may persist and, the opening at the foramen cæcum being closed, may develop into a cyst. Such a cyst may lie in any part of the duct. As the hyoid bone develops it comes into close relation with the duct, which usually passes close behind it but may occasionally run in front, and at times is even said to pass through the middle of the hyoid bone. Cysts may be supra- or infra-hyoid. (Fig. 845.) If above, they are generally in the substance of the tongue and may be superficial, when they form a swelling below the mucosa which may project sufficiently to cause difficulty in swallowing or breathing. If deeper, they form a mass which may be visible or palpable deep in the submental region, or palpable between one finger on the tongue and one externally. They may interfere with the movements of the tongue and cause difficulty in swallowing, and so necessitate operation.

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* J. Walton, *Brit. Journ. Surg.*, 1931, xix, No. 74, 285.

Infrahyoid cysts may appear in any area between the hyoid bone and the isthmus of the thyroid gland. They may be in the midline or, more commonly, especially in the lower part, be rather to the left; as they enlarge they tend to become inflamed and break down, as a result of which, or of unsuccessful operations to remove them, a fistula forms, the cysts alternately filling up and discharging. The condition can only be treated by complete removal.

Accessory and ectopic thyroids, like thyro-glossal cysts, may appear in any part of the line of the thyro-glossal duct. They may form a projection above the tongue in front of the epiglottis (lingual thyroid), or a rounded, firm tumour in the submental region. These suprahyoid varieties not uncommonly form the only portion of thyroid present, and this has led to the belief that the thyroid gland is developed from the central *anlage* alone. They are much more common in females; indeed, it is doubtful if males are ever affected. They are small at birth but enlarge at puberty, and may then cause much dyspnœa and difficulty in speaking and swallowing. They may thus necessitate operation, but attempts should always be made to palpate thyroid tissue in the normal area. If not felt, only a minimal amount of the tumour should be removed and those tumours in the submental region, if only causing minor symptoms, should be left. In the infrahyoid region accessory thyroids, if present, tend to be smaller and the normal thyroid is more likely to be present. They may also occur below the thyroid in the supra- or retro-sternal regions, in the latter region being perhaps as low as the thymus. In some cases accessory thyroids may occur in the lateral region. They then lie in the anterior triangle of the neck, either deep to or along the anterior border of the sterno-mastoid. Several may be present, and closely resemble enlarged lymphatic glands. The presence of these bodies strongly supports the view that the lateral lobes of the thyroid are developed by an independent lateral *anlage*. Accessory or independent thyroids are liable to the same diseases as the thyroid gland itself and may be the seat of colloid or adenomatous enlarge-

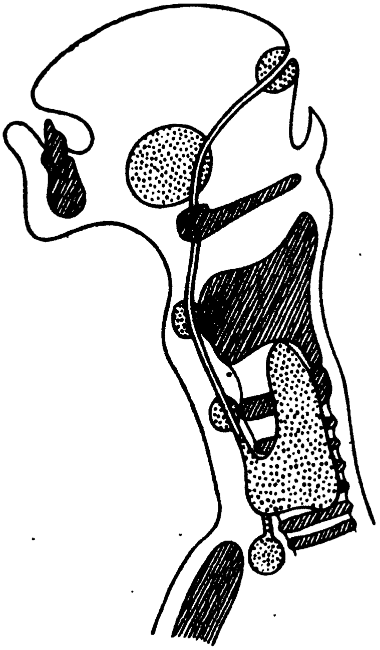

Fig. 845.—The common sites of thyro-glossal cysts and aberrant thyroids.

ments. It is such changes which usually call for operation. The lateral aberrant thyroids are especially apt to become malignant, and for this reason should be removed.

Choice of anæsthetic.—Infrahyoid cysts or accessory thyroids will not necessitate any special anæsthetic for their removal, but the operation may involve a prolonged dissection and therefore a general anæsthetic with open ether, ether vapour or gas-and-oxygen will generally be found the most satisfactory. Cysts or tumours within the substance of, or projecting from, the dorsum of the tongue are likely to interfere with respiration, and therefore intratracheal anæsthesia will often be found the safest procedure.

Operative technique.—Projecting lingual thyroids and small superficial cysts may best be removed through the mouth. The jaws should be separated by a gag, and the tongue drawn forward as fully as possible by two sutures passed, one on either side of the swelling, as far back as possible. The mucosa is divided on either side of the tumour, which is then excised or enucleated. If no normal thyroid has been felt, it is better to excise only the projecting portion of the lingual thyroid and to attempt to leave some portion of gland deep in the substance of the tongue. Hæmorrhage from the cavity may be considerable and for this reason small cysts only should be removed by this method. Any large vessels are ligatured and the walls of the cavity and the edges of the mucosa sutured with catgut.

Larger cysts and tumours in the substance of the tongue should be removed from below. The head being extended over a sandbag, a somewhat curved incision is made across the neck in a natural fold at the level of the hyoid bone. In no operation for any of these lesions should a vertical or oblique incision be made, as the resulting scar may cause great deformity. The upper flap is dissected upward, the mylo-hyoid raphé divided, and the fibres of the genio-hyoglossus separated. The cyst is carefully dissected out, this being aided by pressure with the finger of an assistant on the dorsum of the tongue. If a small portion of the mucosa of the tongue is adherent, this may be excised with the deep portion of the cyst. The resulting opening into the mouth is closed with plain catgut, the cavity in the muscles is obliterated with chromic gut sutures, and the skin is united. If the cavity be large a small tube may be inserted for 24 hours.

Infrahyoid cysts and tumours should also be approached by a collar incision. With an unbroken cyst this should be placed above the cyst so as to be near the hyoid bone. If a fistula be present, the centre of the incision should encircle the opening of the fistula. The lower part of the cyst or fistula should then be freed, the sterno-hyoid and sometimes the sterno-thyroid muscles being separated. As the lower and lateral portions are freed, an upward prolongation will become visible; this must be carefully traced up and wholly removed. If any portion is left, the condition is certain to recur. On one of my cases there had been fifteen previous operations. The process will pass up to the hyoid bone and, in my experience, nearly always passes behind it. Usually it can be completely removed by elevating the hyoid bone with a button-hook retractor, but if adherent or passing very far up, the central portion of the hyoid bone should be excised. The flaps are replaced and sutured. Aberrant thyroids, if centrally placed, should be excised in a similar manner. Those placed laterally may require a more prolonged dissection, as several may be present. Owing to their tendency to become malignant they should all be removed, provided the normal thyroid is present, and any suspicious glands should be removed at the same time. The operation will resemble that for enlarged cervical glands. A retrosternal thyroid, if enlarged, will be removed, as is a retrosternal goitre.

Results.—These operations all require care and patience but do not present any special dangers. Lingual thyroids and cysts may lie in a vascular bed and care must be exercised in controlling hæmorrhage. If the mucosa has been in part excised when removing a cyst from the neck, the opening must be carefully sutured or sepsis in the large cavity may result. The risk in the infrahyoid group is that a small portion of the duct may be left and the condition recur. This can only be prevented by careful dissection. In my own series of twenty-one cases recurrence took place in two, but was cured by a second operation.

INFLAMMATORY LESIONS OF THE THYROID

THYROIDITIS AND LYMPHADENOID GOITRE

Indications for operation.—Inflammatory changes in the thyroid are very uncommon in British practice. Infection may rarely spread to the gland from some neighbouring tissue such as a lymph gland. Chronic suppurating thyroiditis, according to de Quervain *, is nearly always tuberculous. If limited to one lobe it should be excised; if diffuse, climatic and X-ray treatment are indicated. Rarely, a gumma or hydatid cyst may be found. A gumma, if correctly diagnosed, will not call for operation, and a hydatid cyst will in all probability be mistaken for a cystic adenoma and treated on this assumption. Apart from these conditions, common to any viscus, diffuse inflammation of the gland may also be found.

1. Non-suppurative thyroiditis may occur in a previously healthy gland and may then arise during an acute infection. According to de Quervain (*loc. cit.*), if occurring with rheumatism, malaria or measles, the condition does not proceed to suppuration, but if due to scarlet fever, typhoid or puerperal fevers, suppuration is almost invariable. The primary simple variety usually subsides within a week and thus will not necessitate operation. If occurring in a thyroid the seat of previous disease, which is usually a diffuse adenomatous goitre, the inflammatory swelling may cause so much pressure

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* "Goitre," 1924.

upon the trachea that operative interference may become urgent. A more chronic condition is that known as wooden thyroiditis or Reidel's disease. This consists of a firm, hard enlargement of the thyroid, occurring in either sex and usually commencing in a previously healthy gland, composed of inflammatory cells and tending to spread to the surrounding tissues. It forms a hard enlargement affecting the whole gland, and is often mistaken for carcinoma, but is smooth on the surface. It has a tendency to lead to myxœdema and thus operation is not usually advocated, but Joll* is of the opinion that resection of a large portion of the gland inhibits the process. Many think it is rapidly improved by X-rays, and this has been my own experience, but since no portion has been removed it is possible that some cases so treated were carcinomatous, as some examples of this latter disease also rapidly improve with X-ray therapy (*see* Carcinoma, p. 1780).

Here may be considered a relatively rare condition, to which Joll has especially called attention, known as lymphadenoid goitre. Often regarded as inflammatory, Joll has shown that it is due to a lymphocytic infiltration leading to fibrosis. It is more common in women at the time of the menopause and, unlike Reidel's disease, is limited to the gland. It rarely causes pressure, but is generally associated with some myxœdema. For this also he advocates subtotal thyroidectomy, but, owing to the tendency to myxœdema, many do not advise surgical treatment.

2. Suppurative thyroiditis may occur in a previously healthy gland, as already stated, but is more common in thyroids which are the seat of an old goitre. It is more common in old cysts with thick fibrous capsules. In such cases the abscess, whether rupturing spontaneously or opened surgically, may be followed by a persistent sinus, usually due to the presence of calcareous particles.

Operative technique.—Any operation for the above conditions will usually be performed for the relief of urgent symptoms, and therefore but little preparation can be made. In non-suppurative thyroiditis there will generally be much dyspnœa, with congestion and dilatation of all the vessels. For this reason no attempt must be made to operate through a small incision. A transverse incision should be made in the neck, in the fold of the skin opposite the centre of the isthmus, the " collar " incision (Fig. 846). It should be at least 3 in. long, and the underlying platysma should be divided at the same time. The anterior jugular veins, which will probably be much dilated, should be divided between ligatures, and the pretracheal muscles divided down to the capsule of the gland. A separation, instead of division, of the muscle-fibres should never be attempted in this type of case. It is essential to obtain a good view, as the amount of bleeding will always make the operation difficult. When the isthmus of the thyroid has been laid bare, a wedge about ½ in. wide should be removed as deep as the trachea. This step will always be associated with considerable hæmorrhage, which may to a certain extent be controlled by clamping the vessels before the incision is made into the gland. As soon as the wedge is removed, the pressure upon the trachea will be relieved and the congestion will abate. For this reason a tracheotomy is very rarely necessary ; owing to the size of the isthmus it is rarely possible to perform it as a primary step, and after the removal of the isthmus it is generally unnecessary. All clamped vessels should be carefully ligated, a tube inserted down to the cut surface of the thyroid, and the pretracheal muscles and skin carefully sutured.

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* " Diseases of the Thyroid Gland," 1932.

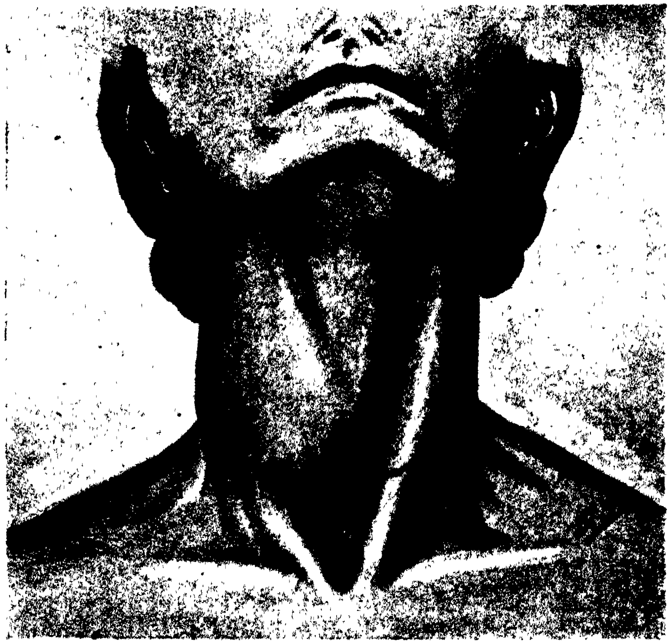

Fig. 846.—Collar incision.

If there be suppurative thyroiditis, operation should, if possible, always be delayed until the abscess is localized. An incision should then be made over the most prominent area, and should always lie in the line in the fold of the neck, as thereby scarring will be reduced to a minimum. When the skin has been incised the muscle-fibres should be carefully separated down to the surface of the gland, and an incision made into the abscess cavity. If the anatomical structures are ill-defined, owing to the inflammatory change, it will often be safer to make this opening with a pair of sinus forceps. A tube should be inserted into the abscess and the wound closed. When there is suppuration within an old fibrous-walled cyst, a larger incision should be made and the gland fully exposed. It will then not uncommonly be possible to enucleate the whole cyst with its contained abscess

The gland is then treated as after enucleation of a simple cyst, but must always be drained. The inflammatory process is apt to recur.

SINGLE ADENOMATA AND CYSTS

Indications for operation.—It is somewhat doubtful whether the localized masses which are found in the substance of the thyroid are really true adenomata or whether they are regeneration nodules. They frequently occur in association with diffuse enlargements of the gland, and more than one may be present. The single masses are, however, rare in endemic areas, and often have a definite fibrous capsule. As they increase in size they, in nearly all cases, undergo changes. Most commonly the walls of the acini break down and cystic spaces are formed, so that ultimately the whole mass may form a single cyst. Hæmorrhages may occur into the tumour or cyst and cause a rapid increase in size. More rarely, the cyst may become inflamed and even suppurate. In other cases the tumour is richly cellular, often being formed of a more embryonic type of cell, the so-called fœtal adenoma of Plummer. In such cases toxic symptoms arise which may progress to complete auricular fibrillation. One form of carcinoma arises in an adenoma and especially in the richly cellular type. The risk of malignancy in all adenomata seems to be about 5 per cent. If they were unquestionably adenomatous, operative treatment would be indicated in every case owing to the certainty of progression and the risk of malignancy. A few of the single localized adenomata appear, however, to yield to medical treatment, as do a larger number that occur in association with a diffuse enlargement. It may be said, then, of the localized adenomata that if they are hard and sharply defined, they should be treated by surgical methods. If, on the other hand, they are softer, are less sharply defined, and are not giving rise to symptoms, medical treatment should first be tried. The indications for operative treatment may be considered as follows:

1. *Failure to obtain relief by medical treatment.*—If, in a patient with a soft adenoma, a course of medical treatment has failed to give relief, operation should be undertaken. The medical treatment must consist in the removal of any septic focus, sterilization of the drinking-water, and, if there be evidence of hypothyroidism, in the administration of small doses of iodine. McCarrison,* acting on the assumption that the infection is within the intestinal canal, has advocated the administration of thymol, or even a vaccine. The former in 2-gr. doses three times a day appears to be efficacious in many cases, although it will probably have to be continued over a period of several months.

2. *Steady increase in size, with resulting deformity.*—Sometimes a localized adenoma will cause considerable deformity with no other symptoms, the tumour forming a rounded prominence 5 or 6 in. in diameter. In such cases it should be removed, especially if it has become cystic. An operation will lead to certain cure, and the mere

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* *Proc. Roy. Soc. Med.*, Feb., 1912, v (Sect. Med.), 38.

presence of so large a tumour is evidence that medical treatment has failed.

3. *Dyspnœa.*—This is the most certain indication for operation. Even if it does not greatly interfere with the patient's life, it is evidence that pressure is being caused, and that the tumour is enlarging. Should the dyspnœa interfere with the patient's employment, the necessity for operation will be much more urgent. The condition may have been allowed to progress so far that the patient cannot sleep when lying down. In such cases operation should be undertaken as soon as possible, for at any time an attack of severe dyspnœa may occur and, if it takes place at night, may be fatal before help can be obtained.

Acute temporary attacks of sudden and suffocating dyspnœa may at times occur with relatively small adenomata, and probably depend on a sudden enlargement due to œdema or increase of vascularity. Similar attacks with cystic tumours are probably due to small hæmorrhages into their interior, but with a larger cyst a hæmorrhage into the cavity may so greatly increase the pressure as to cause a fatal dyspnœa. Attacks of this nature are more common and are more likely to be serious with a retrosternal goitre, for in this case free enlargement forward is prevented by the sternum. A retrosternal goitre may also be sufficiently freely movable to be thrust up into the neck on expiration, and to be drawn down into the thorax, where it obstructs the trachea, during inspiration (plunging goitre). There will then be marked stridor and dyspnœa with each inspiration. Any of the above varieties of dyspnœa must be regarded as grave danger signals, and an operation should be performed at an early date to anticipate a fatal attack.

4. *Pressure on the blood-vessels.*—This complication is rare. Occasionally the patient is unable to stoop without the sensation of congestion in the head. This is probably due to pressure on veins, and should be regarded as a definite indication for operative treatment.

5. *Pressure on other structures.*—Sometimes an adenoma may give rise to difficulty in swallowing, or to alteration in the voice, or to difficulty in speech due to pressure on the recurrent laryngeal nerve. These latter symptoms were at one time regarded as evidence of the onset of carcinomatous changes, but it is now realized that if an adenoma be situated far back it may enlarge between the œsophagus and trachea, and may give rise to dysphagia or to pressure on the recurrent laryngeal nerve.

6. *Pain.*—Patients will often state that an adenoma of the thyroid gives them a considerable amount of pain, even when the tumour is relatively small and causing little or no pressure. With the presence of carcinomatous changes the pain is likely to be increased, from the involvement of surrounding tissues. Pain, therefore, is an indication for early operative interference lest the condition should be malignant. It may be possible to remove a carcinoma before the surrounding tissues have become widely involved.

7. *Toxic symptoms.*—Occasionally a localized or a large and degener-

ated adenoma will give definite symptoms of hyperthyroidism, although the clinical picture is but rarely sufficiently developed for the case to be regarded as one of exophthalmic goitre. These symptoms are, however, less frequent than with the generalized adenomatous goitres. In both cases operative treatment will lead to a rapid improvement, although in the latter variety, if the condition be left for too long, there may be marked cardiac changes which may be permanent. Toxic symptoms with a localized adenoma, as Wilson and Plummer have shown, suggest carcinomatous changes.

Choice of operation.—Single adenomata should be shelled out of the substance of the gland. They can, as a rule, be easily removed by this method without destroying any portion of the normal tissue. When the cavity from which they have been removed is sutured, the outline of the gland is restored, and there is no resulting deformity or pressure. At times the adenoma may be so large that practically the whole of the affected lobe is destroyed ; in this case the only feasible operation is to remove the greater part of the lobe with the adenoma, leaving only a thin slice of the lobe on the posterior surface. If there be a large number of adenomata in association with general enlargement, it will be preferable to perform a wedge resection of each lobe, the adenomata being removed together with a wide section of the enlarged gland (resection enucleation).

Preparation.—But little special preparation is required. If there be any catarrhal bronchitis the patient should be kept in bed for several days before the operation, which should always be preceded by a hypodermic injection of atropine, so as to diminish the secretions. Toxic symptoms may be overcome by a course of treatment with Lugol's iodine, given as for true exophthalmic goitre. The skin of the neck should be prepared by painting it with a 2 per cent. solution of iodine in rectified spirit. The first coat should be applied the night before, the second one early in the morning of the operation, and the third while the patient is on the table. After the first two coats the skin is covered with a sterile towel, which is bandaged in place.

For **anæsthesia**, my own preference is either warmed ether vapour given after a preliminary injection of $\frac{1}{4}$ gr. of morphia and $\frac{1}{100}$ gr. of atropine, or for gas and oxygen after a preliminary injection of $\frac{1}{3}$ gr. of omnopon and $\frac{1}{150}$ gr. of scopolamine. If there be any evidence of pressure upon the trachea, an intratracheal anæsthetic should be administered. Some surgeons, however, prefer a local anæsthetic for all thyroid operations. Chloroform or chloroform mixtures should never be used. When the patient is placed upon the operating-table a small sandbag should be inserted beneath the shoulders, so that the head drops back and the neck is extended. The extension of the head should be carried as far as possible without causing respiratory distress, and the anæsthetist will say when it has been carried sufficiently far. A folded towel is placed across the face, and its lower border sutured by three stitches to the skin immediately beneath the chin and the angles of the jaw. By this means the towel is prevented from slipping, and the anæsthetist can manipulate the mask and the patient's jaw without interfering with the operative field. Towels are then placed on either side of the neck and across the thorax.

Operative technique.—Every operation upon the thyroid gland should be performed through the "collar" incision, introduced by Kocher (Fig. 846, p. 1752), which affords admirable access to the gland and leaves but little scar. If the adenoma be very small and the operation be performed in the absence of pressure symptoms, it may be sufficient to make an incision about 2 in. long. If, however, there be any evidence of dyspnœa, the incision must always be sufficiently long to enable the surgeon to explore the whole of the gland, otherwise a superficial adenoma may be removed and a large retrosternal goitre of the other lobe, which is really the cause of the pressure, may be entirely overlooked. A 5-in. incision will usually be required for this purpose. The incision is carried sufficiently deep to divide the platysma, and the upper and lower flaps are reflected. (Fig. 847.) The pretracheal muscles are thus exposed and, if there be one small adenoma, the fibres may be separated vertically. If the tumour be large or there are more than one, it is wiser to divide the muscles transversely (Fig. 854, p. 1774) in one sheet as in the operations for adenoparenchymatous or exophthalmic goitre. If divided vertically, the muscles are widely separated by retractors and the pretracheal fascia is carefully divided until the thin-walled thyroid vessels are exposed. (Fig. 848.) When the correct level is reached a finger may

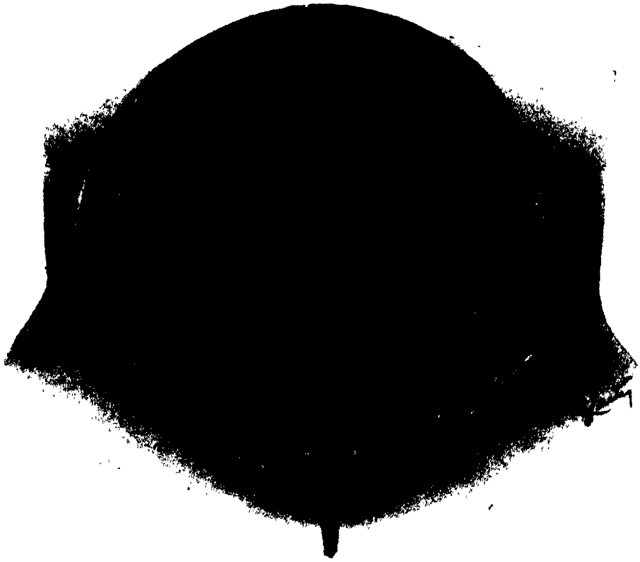

Fig. 847.—Reflection of skin flaps with platysma.

be inserted along the gland, and the greater part of it explored. If there are but one or two small adenomata, the thyroid gland is incised

Fig. 848.—Resection: enucleation of thyroid. Separation of pretracheal muscles and exposure of thyroid.

Fig. 849.—Enucleation of the adenoma.

until the glistening capsule of the tumour is seen. (Fig. 849.) The whole success of the operation depends upon commencing the enucleation in the correct plane, and it is thereforre essential to recognise the capsule of the neoplasm before separating it from the tissue around. The separation may begin with a blunt dissector, but is continued in its deeper part with a scalpel. Care must be taken that the adenoma or cyst be not ruptured, for if this occurs it will be much more difficult to determine whether the whole of it has been removed. If it be very large, and the anterior surface of the thyroid be much stretched, it will be better to excise a wide ellipse of the anterior surface of the gland with the tumour. An incision should then be made well to one side of the thinned-out area through the normal thyroid tissue, and deepened until the capsule is seen. A second incision is then made on the opposite side, and thus, when the adenoma is shelled out, a wide ellipse of the adherent thinned-out and fibrous anterior layer of the gland is taken away with it.

Fig. 850.—Restoration of lobe after enucleation of adenoma.

The cavity which is left in the lobe is sutured with catgut. A long suture is taken and tied at one extremity ; it is then passed from side to side through the lobe and the cavity as a running mattress-suture. (Fig. 850.) When it reaches the other extremity it is made to return as a running whip-suture, which unites the cut anterior edges of the incision, and finally is tied to the original end of the suture at the lower part of the lobe. By its means the walls of the cavity are drawn firmly and evenly together and all hæmorrhage is prevented. If the adenoma has been small and there have been no toxic symptoms or hyperthyroidism, no drainage will be required, but if large or there have been any signs of hyperthyroidism, a small tube should be placed down to the line of suture. The pretracheal muscles are drawn together with one or two interrupted catgut sutures, the cut platysma is joined with a running catgut suture, and the edges of the skin are carefully united with an intradermic suture of fine catgut. The tube should be removed after 48 hours, and no special after-treatment is required.

Results.—An operation for the enucleation of a single cyst is associated with very little risk. Danger to life arises chiefly from complications. A large cyst or adenoma may cause much dyspnœa, but the more severe forms, especially as seen with retrosternal goitre, are generally found with multiple adenomata and require a more extensive operation than simple enucleation, and the same is true of cases with definite toxic symptoms (*see* p. 1770). In my own series of 369 cases in which enucleation for adenoma was performed, there were four deaths. In two of these fatal cases there was considerable dyspnœa and the adenoma was so large that the enucleation meant removing practically the whole lobe ; one had advanced toxic symptoms with complete auricular fibrillation ; and the fourth died on the thirteenth day from pulmonary embolism. If the adenomata are in fact regeneration nodules, a recurrence might be expected. This is certainly true of multiple adenomata, but is rarely seen with the single lesions ; it only occurred in two of my cases. The thyroid left after operation is nearly normal, but is, of course, not protected from other lesions which may occur in any thyroid. Four of my cases after several years developed true exophthalmic goitre.

COLLOID GOITRE

Indications for operation.—A simple colloid goitre, such as occurs in girls, or more rarely in boys, at or about the age of puberty, has a tendency to resolution under medical treatment, but if not cured small regeneration nodules looking like adenomata are formed. These are multiple and have ill-defined capsules. They steadily increase in size and numbers until the original colloid character is entirely lost and the thyroid becomes a typical nodular or adenoparenchymatous goitre. Wegelin in Berne has found that between the ages of ten and twenty only 36.7 per cent. of all goitres are nodular ; between twenty and thirty, this percentage has risen to 67.4 per cent. ; and during the fourth decade to 75.2 per cent. (Joll). In countries showing only sporadic goitres the nodular variety is rare in the young but it is common in countries where goitre is endemic. The adenomatous masses so formed may undergo all the changes seen in the single adenoma, and the remaining portion of the gland becomes more fibrous until but little remains. In a smaller number of cases the gland becomes more cellular and the condition progresses to a typical exophthalmic goitre. Owing to the tendency to improve with medical treatment but few cases of colloid goitre in this country require operation, which should only be considered under the following conditions.

1. *Dyspnœa.*—A slight amount of dyspnœa will probably be present in all colloid goitres of any size, but if it is only evident on exertion it need not be an indication for operative interference. If, however, it

be sufficient to cause discomfort, if it be steadily progressive, and especially if it interfere with sleep, an operation should be carried out without delay. If no operation be performed, there may be a sudden severe attack, which may occur at night and be rapidly fatal. It is in such attacks that an emergency operation, which is often associated with considerable difficulty, may have to be performed for the relief of the obstruction. It is well to remember that these acute attacks may sometimes occur in young people with only a moderate-sized goitre, but this has probably rapidly increased in size. In most of these cases the trachea is considerably flattened, and, rarely, the cartilage of the tracheal rings may be in large part absorbed so that the wall is quite soft.

2. *Multiple adenomata.*—*See* Nodular or Adenoparenchymatous Goitre (p. 1764).

3. *Hyperthyroidism.*—One of the most unsatisfactory complications that can occur in a simple colloid goitre is the onset of symptoms of hyperthyroidism, and it is for this reason that, although preparations containing iodine or iodides are often useful, great care must be exercised in administering them. Many of the colloid goitres appear to be hastened towards this complication by such treatment. The indications for operative interference in cases of hyperthyroidism will be considered later.

4. *Deformity.*—The deformity of colloid goitre may be very considerable, but, occurring as it does in relatively young patients, it gives rise to but little distress, and since the majority of simple colloid enlargements disappear in about a year, operation will rarely be required for the deformity alone. Cases which persist for a longer period and give rise to more marked deformity are those which are irregular in outline and are associated with multiple adenomata, in which case an operation will be performed rather for the removal of the adenomata than for the relief of the deformity.

Choice of operation.—It was formerly the custom to perform a hemithyroidectomy, removing one lobe and half the isthmus. This operation will overcome the pressure upon the trachea, and will frequently be followed by a rapid decrease in size of the remaining portions of the thyroid, so that the deformity is overcome. It has, however, been abandoned, for the remaining lobe may not return to the normal size, especially if there be multiple small adenomata, or if the thyroid be unusually fibrous. In these circumstances not only will the deformity persist, but it will in fact be increased, for a large unilateral thyroid is more unsightly than an enlargement of both lobes. The operation of choice is that of double wedge resection. With this method the thyroid is reduced to its normal size, all obstruction is removed, and the remaining thyroid is symmetrically placed. It can be so modified that any localized adenomatous masses are removed with the wedge, and thus there is very little chance of recurrence. The only objection is that, if the vessels are not very carefully controlled, it is likely to be associated with considerable hæmorrhage and shock.

Preparation for operation.—This is carried out on the same lines as for an operation for the removal of an adenoma.

Operative technique. 1. **Double-wedge resection.**—This operation, originally introduced by Mikulicz, has been elaborated and perfected at the Mayo Clinic, and the method now usually performed is that described by Balfour.* The usual collar incision is made, and is limited laterally by the external jugular veins. The flaps containing the subcutaneous tissue and platysma are reflected, the upper as high as the thyroid cartilage, and the lower to the sternal notch. The pretracheal muscles are divided transversely in one sheet as in the operation for exophthalmic goitre, and the fibrous covering of the gland is divided. The whole gland is explored, and both lobes are dislocated (Fig. 851.) The first step consists in division of the isthmus; the vessels running along its upper and lower border are clamped, and the isthmus is then divided down to the trachea. The lateral portions of the isthmus are now separated from the trachea, so that the latter is quite free, and the clamped vessels are ligatured. If the goitre is large and vascular, it is now better to ligature and divide the individual vessels of each lobe in a precisely similar manner to that employed with exophthalmic goitre. After this is completed, or before if the thyroid is not very vascular, the right lateral lobe is held up by the assistant and clamps are applied on the vessels. These are attached

Fig. 851.—Wedge resection of right lobe of enlarged thyroid.
(For the sake of clarity a relatively small thyroid is depicted).

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* *Ann. Surg.*, May, 1914, lix, 671.

in two rows, the inner just beyond the junction with the isthmus, and the outer along the external border of the lobe. A large wedge with its base anteriorly and between the two rows of forceps is now resected from the lobe, any adenomata being shelled out together with the wedge. The remaining cup-shaped structure is rebuilt into a compact strip of tissue by a catgut suture passed in the same manner as that used to obliterate the cavity after the removal of an adenoma. (Fig. 850.) It so controls the hæmorrhage that the forceps can often be removed without the necessity of ligating any of the vessels, and at the same time it obliterates the cavity in the centre of the lobe. The reconstructed lobe is allowed to drop back into the space formerly occupied by the enlarged gland. (Fig. 852.) The opposite side is treated in the same way. A tube is inserted for twenty-four hours, and the wound is closed as already described.

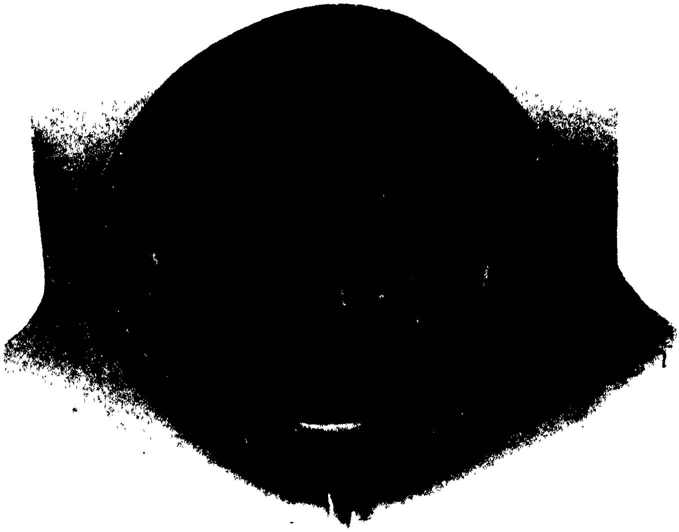

Fig. 852.—Restoration of right lobe after wedge resection.

By this method hæmorrhage is easily controlled, there is no danger of injury to the recurrent laryngeal nerve or parathyroids, all pressure is immediately and completely relieved, and there is no resulting deformity.

2. **Emergency operations for the relief of dyspnœa.**—With attacks of severe dyspnœa an operation becomes one of very great urgency. In some cases, so grave is the condition that the whole of the operation can be carried out without an anæsthetic, and yet the patient survives. Under such conditions great speed is imperative and the routine steps will of necessity have to be modified. The usual collar incision should be made, so that free access can be obtained. This is very necessary, for owing to the venous congestion the field will be obscured by

hæmorrhage, and for similar reasons it is always wiser to divide the pretracheal muscles freely rather than to retract them. As they are divided the thyroid may project forwards, and respiration may commence. The fascia over the gland is next incised and the thyroid dislocated forwards. It will nearly always be found that this completely relieves the obstruction, and respiration can be induced. If no anæsthetic has been given a little gas and oxygen or open ether will now be required. The further steps of the operation can be performed at greater leisure, although it sometimes happens that the airway is only free as long as the lobe is supported. If the enlargement be uniform a wedge resection, by the method described above, will be the most satisfactory. If one lobe be mainly affected a wedge resection should be performed on the enlarged lobe. As a general rule, either step will give complete and permanent relief, and will lead to cure.

Even if the enlargement be almost wholly limited to one lobe a hemithyroidectomy should not be performed, for rarely the respiration may be still impeded after a lobe of the thyroid has been removed because of extreme flattening of the trachea, with absorption of the cartilage, so that with each inspiration the trachea collapses like a valve. It may then be essential, after the portion of the thyroid has been removed, to perform a tracheotomy so that the tube will overcome this collapse. Such an operation should be avoided, for there is grave danger that the relatively large wound necessitated by the excision of the gland will become infected through the opening of the trachea, with serious and perhaps fatal results. The wedge resection of one lobe instead of a hemithyroidectomy will usually prevent this complication, for the built-up lobe will support the thinned trachea and help to hold it open.

From time to time much discussion has arisen as to the value of tracheotomy, and it was frequently advocated that a long flexible tracheotomy-tube, such as König's, should be passed from above the isthmus. Such an operation has nothing to commend it, for, owing to the enlargement of the thyroid, it may be almost impossible to enter the trachea. The obstruction is caused by an enlargement of the thyroid, and the correct treatment is to remove the obstruction.

After-treatment.—The after-treatment of an operation for colloid goitre presents little difficulty. Morphia should be given sufficiently freely to maintain the patient's comfort, and liberal amounts of fluid should be administered. If there has been any evidence of hyperthyroidism before or after the operation it will chiefly be shown by an increased rapidity in the pulse, by a rise in the temperature, by restlessness and increased sweating. The restlessness may be controlled by larger doses of morphia, and the toxæmia will have been controlled by the previous administration of Lugol's iodine. Large amounts of fluid should be given, one pint of normal saline with 5 per cent. glucose being administered per rectum three times a day, and the patient being encouraged to drink large quantities. In such cases the wound should be drained until the temperature and pulse have been normal for at least twenty-four hours.

Results.—Operations for a colloid goitre are associated with a somewhat greater risk than those for a simple adenoma because of the greater size of the gland, its increased vascularity, and the presence of obstructive symptoms. The operation may in itself be of considerable severity. In my own series the operative mortality was 4 per cent., but there is no doubt that this could be almost entirely abolished if operation were undertaken as soon as it became evident that the dyspnœa was increasing and that the condition was not being relieved by medical treatment. Balfour (*loc. cit.*), in giving the statistics of the Mayo Clinic, states that 295 cases were operated upon by the double-wedge resection and gave satisfactory results. If hemithyroidectomy be performed, a certain number of cases will retain their enlargement of the opposite lobe and will thus have a considerable amount of deformity, which may persist for many months or even a year. With double-wedge resection this difficulty is overcome. It has been stated that the removal of large portions of the thyroid may be followed by myxœdema. This possibility has, I believe, been greatly exaggerated. In my own experience it has been very rare, and has only occurred in a few cases which were operated upon in the belief that they were simple colloid goitres, pathological investigation showing that they were very atypical.

NODULAR OR ADENOPARENCHYMATOUS GOITRE

Indications for operation.—This is the common form of goitre in endemic countries, where it may be nodular from the onset, but in countries where the disease is only sporadic, it is the late result of an untreated colloid goitre. The rounded masses, which appear to be of the nature of regeneration nodules, may be few or many, and resemble adenomata, but when small have ill-defined capsules. In the earlier stages the remaining portion of the gland usually shows a colloid change but later it becomes fibrous and atrophic, so that, as the nodules increase in size, the goitre may not only be very large but also very irregular in shape. As the adenomatous masses enlarge they may undergo all the changes seen in single adenomata ; the walls of the acini may break down, forming cystic spaces filled with colloid material into which hæmorrhage may take place, the mass may become more richly cellular and be associated with thyrotoxic symptoms, portions generally in the centre may become fibrous, and later calcareous or malignant changes may arise.

As a general rule, once a large nodular goitre is formed the mass will not be influenced by medical treatment, and therefore most cases will require surgical intervention. There is, however, one marked exception, that is the nodular goitre which may be found with cretinism and which may disappear with almost miraculous rapidity on the administration of thyroid extract. Some small nodular goitres may also remain quiescent for a long period, and although causing a mild degree of deformity, will give rise to no symptoms and therefore may not necessitate operation.

The symptoms calling for operation may depend on the irregularity of the growth or on the secondary changes. The large nodules may protrude forward and, although causing in this case but little pressure, form a most unsightly tumour which may even be pedunculated. They may grow outward so that the carotid artery is displaced outward, or project inward so that the trachea is seriously displaced or compressed, or the mass may spread backward and inward behind the trachea or even behind the œsophagus. At times a single mass or a portion of the whole goitre may extend downward behind the sternum into the mediastinum, forming a retrosternal goitre. When still comparatively small, such a mass may be drawn down into the thorax on inspiration and forced up into the neck on expiration or coughing, forming the so-called plunging goitre. The chief clinical symptoms calling for operation are somewhat similar to those seen with a simple adenoma but are generally more marked. They may be considered as follows :

1. *Deformity.*—Often a patient will seek advice simply because of the size of the goitre. The large irregular mass may be very unsightly, especially if very irregular, if asymmetrical, and if projecting forward. Since medical treatment is of no avail and since, if it is left, one of the more serious complications is almost certain to arise, operation should be advised.

2. *Dyspnœa.*—The large irregular masses, especially one growing downward to form an intrathoracic goitre, and unable to enlarge forwards, are very apt to compress and distort the trachea, which may be flattened from side to side to form the so-called "scabbard" trachea, or widely curved and displaced to one or other side. If the intrathoracic mass is the only one in the thyroid, it is likely to be overlooked, but in practically all cases may be made evident by an X-ray investigation. As with simple adenomata and colloid goitres, acute attacks of dyspnœa may occur from hæmorrhage or œdema.

3. *Pressure upon blood-vessels.*—Although the carotid arteries may be displaced far out, there is rarely any evidence of their being compressed. Venous obstruction is, however, common, this especially with an intrathoracic goitre, which may cause great enlargement of the veins over the goitre, in the neck and even over the upper part of the thorax.

4. *Pressure on other structures.*—Like single adenomata, large irregular goitres may cause pressure on the œsophagus or on the recurrent laryngeal nerve. At one time pressure on this nerve was regarded as a sign that the goitre was carcinomatous but it may unquestionably occur with simple goitres. Its presence cannot be absolutely determined by the symptoms and it is therefore better in all cases to make a laryngoscopic examination.

5. *Inflammatory changes.*—A large nodular goitre may rarely become

the seat of acute inflammation and even progress to suppuration and, causing acute dyspnœa, may necessitate an urgent operation.

6. *Carcinomatous changes.*—Carcinoma may not uncommonly occur with a nodular goitre. (*See* p. 1780.) In such cases the change may pass unnoticed until late, but if the goitre has begun to grow more rapidly, especially in one area, if it has begun to give pain, and if the affected area is hard and nodular, a carcinomatous change should be suspected and an operation performed at an early date.

7. *Thyrotoxicosis.*—This change is common in long-standing nodular goitres (*see* p. 1770) but may occasionally be seen in the early stages. The picture is rarely that of a complete hyperthyroidism and I am doubtful if exophthalmos ever occurs unless there is a change in the general stroma of the gland. The effects are chiefly seen in the cardiovascular system, one of the commonest causes of auricular fibrillation being the presence of a nodular goitre.

Preparation for operation.—These patients may need prolonged and careful preparation. If possible, no operation should be performed if there has been any recent infection. A long-standing nodular goitre may rapidly increase in size during pregnancy and lactation. As a general rule, however, such an enlargement does not cause acute symptoms, and as the goitre may rapidly diminish in size after lactation it is usually better to wait. Acute symptoms may necessitate intervention which, however, is likely to cause a premature birth. If there are severe cardiac symptoms, prolonged rest and medical treatment may be required before operation, and the same is true if there be much bronchitis, unless the latter is manifestly due to pressure on the trachea, when surgical relief should be given as soon as possible. If there be active thyrotoxicosis preparation should be carried out on the same lines as for an exophthalmic goitre.

Anæsthetic.—The choice will be on the same lines as for an adenoma, but infiltration methods and preliminary narcosis should be used in the presence of thyrotoxicosis. The patient should, in fact, be treated as for exophthalmic goitre. If there is dyspnœa, and more especially if there is compression and distortion of the trachea, a tracheal tube should be inserted and intratracheal anæsthesia used.

Operative technique.—The position on the operating-table will be similar to that for an adenoma, and a wide collar incision should be made ; the inner margins of the sterno-mastoid muscles are freed with a few cuts with the scalpel and the muscles retracted outwards ; the two anterior jugular veins are divided between ligatures, and the pretracheal muscles divided transversely in one sheet. (Fig. 858.) It is never wise to approach the thyroid in these cases by separating the fibres of these muscles vertically, for a full investigation of the whole gland is required. The middle thyroid veins should now be ligatured and divided on each side, and the lateral lobes dislocated forward. This will not only give a free exposure of the whole gland

and allow the size of the goitre (which may be enormous) to be determined, but will often free the trachea of pressure and make the breathing easier. The subsequent operative steps will depend upon the nature and size of the goitre. If only one or two large adenomatous masses are present, they may be shelled out after a portion of the anterior covering has been excised (resection-enucleation) and the resulting cavities sutured with catgut. If the goitre be relatively small with multiple small adenomata, it may suffice to excise a wide wedge from each lobe, modifying the excision to include any deeper nodules, the wedge being removed between two layers of forceps as in colloid goitre, and the resulting gap closed with a continuous catgut suture. If the lobes so built up are pulled forward, the isthmus should be divided vertically in the midline and freed from the trachea, so that the new lobes are allowed to drop back under the sterno-mastoid muscles. If the lobes are big and very irregular, and in all cases where there is much thyrotoxicosis, the superior thyroid arteries and veins and the inferior thyroid veins should be divided between ligatures, the inferior thyroid arteries ligatured in continuity as they lie on the longus colli muscles outside the capsule of the gland, and a subtotal removal of the gland performed as in the operation for exophthalmic goitre. A tube is now inserted into the suprasternal space, the muscles are sutured with catgut and the skin with interrupted sutures of fine silk.

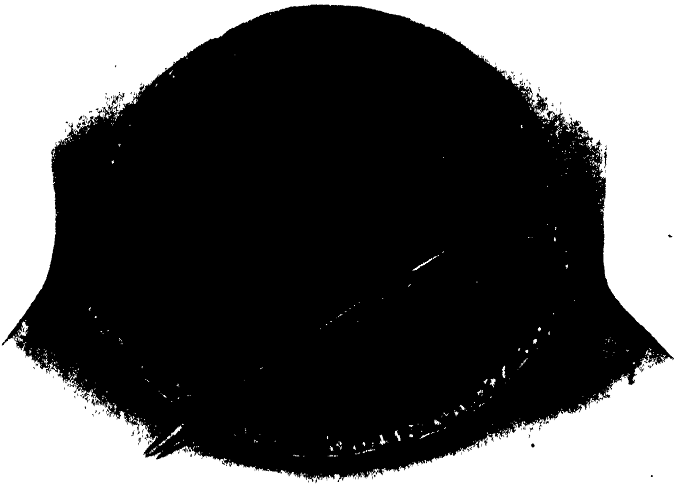

Fig. 853.—Sterno-mastoid muscles freed and anterior jugular veins ligatured and divided.

Operations for retrosternal goitre.—In the above technique the full dislocation of the lateral lobes will reveal a retrosternal mass if one be present, but the diagnosis of such a condition should have been made, or at least suspected, beforehand, owing to the amount of dyspnœa or from a radiological investigation. These goitres nearly always grow from above, and hence the vascular supply can also be generally controlled from above, for very rarely have they developed any vascular attachments in the thorax. If small they can be dislocated upwards into the neck. This may sometimes be difficult as they fit tightly and cannot be gripped. In such cases the device, first advocated by Sir James Berry, of elevating them with the aid of a sterilized tablespoon or shoehorn will often be found very useful. If too big to pass up through the thoracic entry, the vessels entering from above should be ligatured, and the mass should be pulled up as far as possible, incised, and its contents, usually either fluid or colloid, scooped out with the finger. The remainder of the mass can then usually be easily pulled up into the neck. In my own experience, as in that of Joll, it has never been necessary to divide the manubrium sterni vertically, as advised by Sir Thomas Dunhill for very large intrathoracic goitres.

After-treatment.—On return to bed the patient should be nursed in the sitting position, well supported by pillows, and encouraged to drink plenty of fluid. If there has been thyrotoxicosis this should be supplemented by rectal fluid and glucose. Morphia should be given freely. It is very doubtful whether Lugol's iodine is of any value after the thyroidectomy, but many surgeons advocate it, preferably by mouth, but if there be much vomiting it may be administered by rectum or even given intravenously. If there be much reaction with a high temperature and a very rapid pulse, or if auricular fibrillation appear, digitalin, or preferably strophanthin, will often be of great use. In such cases the tube should not be removed until the temperature has fallen to normal. The stitches may be taken out on the seventh or eighth day. With large nodular goitres, especially in young people, a prolonged course of iodine should be given to prevent recurrence. In some cases small doses of thyroid extract may be found necessary for this purpose.

Results.—If operation be performed before the onset of serious complications there should be little danger, but in practice many of these patients are poor surgical risks. They may be elderly with tracheal obstruction and bronchitis, or the heart and kidneys may be functioning poorly, so that the operative mortality is considerably above that of the other forms of non-malignant goitre. This is more so in the sporadic countries. In endemic areas they are more likely to be operated on at an earlier age and before the onset of serious complications. Thus, de Quervain states that in his series of nearly 8,000 cases the mortality was only 0.66 per cent. In my own series, in the majority of whom there was either severe dyspnœa from pressure, considerable thyrotoxicosis or advanced cardiac changes, the mortality was between 7 and 8 per cent. In younger patients with large goitres there is a very definite tendency to recurrence. This can as a rule be controlled by small doses of iodine or thyroid extract. As in all the more extensive operations upon the thyroid gland, there is some little risk of injury to the recurrent laryngeal nerves and to the parathyroid glands.

EXOPHTHALMIC GOITRE

Indications for operation.—The value of surgical treatment for this condition is now universally accepted. Although it would be theoretically more correct to remove the cause of the over-action than to excise a portion of the gland, yet since the cause is at present unknown the results of medical treatment are unsatisfactory. There is with it a high mortality, it has to be continued over a prolonged period during which the patient is debarred from an active life, and there is grave danger in persistent cases of the onset of auricular fibrillation. After a careful consideration of a large number of figures, Joll concluded that rather less than 50 per cent. of patients recover sufficiently, after long periods of medical treatment combined with rest in bed, to resume their normal avocations, and some even of these cases relapse. In the early stages, however, it should always be given a trial. Operation carries with it a definite risk, but of late years, with careful preparation, this has been greatly reduced.

In the majority of cases, therefore, the chief indication for operative interference is the failure of medical treatment. This is not always an easy matter to determine and will depend in part upon the patient's social position. If she has to earn her own living and can ill afford prolonged periods of rest, an operation will be necessary at an earlier date than it would for a patient in more comfortable circumstances who can lead a sheltered and controlled life. In no case should it be delayed until serious organic changes have occurred in the heart and kidneys. If such changes have occurred the operative risk is enormously increased. In fact, Lahey* states that in his series of 15,200 thyroid operations the mortality was mostly due to the patients being allowed to progress to a state of thyroid crisis, but even in such cases careful treatment would extricate the patients from this state and permit operation with a mortality of only 3.5 per cent. In such advanced cases the condition will inevitably progress unless operation is undertaken, and it should therefore be carried out after the risks have been carefully explained to the relatives and after prolonged and careful preparation. Most surgeons would to-day agree with Sir T. Dunhill who even in 1909 stated, " I would go so far as to say that no case, unless almost moribund, is too far advanced to obtain immense relief from operation." Even in some early cases there may be a severe and very rapidly progressive thyrotoxicosis which may threaten the patient's life, operation being, therefore, indicated. Here again there must be most careful and meticulous preparation before operation.

If there are marked mental symptoms, an operation should not be advocated. It has been my experience that such patients, and especially those who have shown a suicidal tendency, are not only bad surgical risks but are not improved in this respect and their mental condition may indeed be further impaired. It is probable that the mental changes are not directly dependent upon the thyrotoxicosis.

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* *Surg, Gyn. and Obst.*, Feb. 5, 1937, lxiv, 304.

Every case of exophthalmic goitre shows a periodic variation in the degree of toxicity. The variation is in part due to the length of time the disease has existed and is in part seasonal, these patients being always worse in very hot weather. It was at one time, therefore, of considerable importance to select the most appropriate time for operation. With modern improvements in the preparation, and especially with the careful use of iodine, the patients can be more readily fitted for operation and these factors become of secondary importance.

Type of disease.—It is becoming the custom to-day to group together all cases with thyrotoxicosis as "toxic goitre," although they are still often distinguished as primary and secondary, the former including all cases of true Graves's disease and the latter examples of adenomata or adenoparenchymatous goitre in which the toxicosis has developed as a secondary manifestation. Clinically, however, the three following varieties may be recognized:

(1) *The vascular type.*—In this variety the patient is usually young, the thyroid is relatively large, vascular, and pulsating, and the pulse is generally rapid. Exophthalmos may be pronounced, but nervousness, wasting, and intestinal symptoms, although present, are not marked. In some cases the hyperthyroidism is manifest from the inception of the disease; in others it appears to arise in a case of simple colloid goitre but these cases, once the disease is established, differ in no way from the others except in the history and perhaps in the presence of a somewhat larger goitre. It is in this type that the most rapid and satisfactory results are obtained from operative interference.

(2) *The nervous type.*—This condition is more frequently seen in older patients, who are indeed often at or about the age of the menopause. The thyroid is often smaller and less vascular, and the pulse is not so rapid. The patient is, however, extremely nervous, and can barely sit still for a moment. There may be distinct mental changes. After operation the progress is much less rapid, and a relatively long period may elapse before the patient is able to take up her normal duties. If the mental symptoms are marked, greater caution should be exercised in advising an operation.

(3) *Hyperthyroidism secondary to a chronic goitre.*—This is the condition usually described as a secondary thyrotoxicosis or toxic goitre. The adenoparenchymatous goitre may have been present for years before there is evidence of hyperthyroidism, which is always incomplete. In fact, in my experience, if exophthalmos be present it always indicates a change in the general substance of the gland, and therefore the local removal of one or more adenomata will be insufficient to cure. It may be associated with definite pressure symptoms and, if not surgically treated, is likely to lead to profound cardiac changes.

In advanced cases, therefore, the patients may be very bad surgical risks, but in early cases where the toxæmia is present with only one or two adenomata, the cure after removal is rapid and complete.

Although partial thyroidectomy can be safely performed on a patient with Graves's disease, any other operation on the same patient will be associated with considerable risk. The shock and fright of any operation produces a severe hyperthyroidism, but with thyroidectomy this is diminished by the partial excision and the drainage of the secretion from the wound. Wherever possible, it is preferable to operate on the thyroid first, and six months later to perform whatever other operation is required. This is especially applicable to gynæcological conditions, which are not infrequently associated with Graves's disease.

Choice of operation.—The dangers of operative treatment are greatly increased by rough handling and by compression of the thyroid gland. If there be severe hæmorrhage, not only is the danger of operation increased, but there is always a much more severe post-operative reaction. . It is doubtful whether this is due to the actual loss of blood or to the rough handling which is often required in order to control the hæmorrhage. An operation must be so conducted that these two dangers are reduced to a minimum but, at the same time, sufficient of the gland must be removed ; for this reason neither unilateral nor bilateral wedge resection should be performed. *Subtotal thyroidectomy must be the operation of choice*, and each step must be slowly and gently carried out, the individual vessels being securely ligatured before they are divided, and care being exercised never to compress the gland. In certain cases ligature of vessels or X-rays may be of value, but usually only as a preliminary to operation. These methods will be considered later, for unless there be some definite contra-indication, subtotal thyroidectomy is the operation of choice. With careful preparation the patient can usually be so improved that the operation can, in the great majority of cases, be performed without undue risk.

Preparation for operation.—It was formerly my custom never to inform a patient that an operation was about to be performed, but to-day so many sufferers eagerly seek operation that this precaution is rarely necessary. The patient is admitted to the home or hospital and kept in bed for a week on a plain, nutritious diet, with plenty of fluid but no tobacco or alcohol. No treatment is given unless complications are present. During this period of observation an estimate can be made of the amount of hyperthyroidism while the patient is at rest. At the end of a week the administration of Lugol's iodine is commenced. In mild cases 3 minims of the solution in one ounce of water is given three times a day, the dose being increased daily by 1 minim t.d.s. At the end of a further week the symptoms will, as a rule, have so greatly improved that the operation can be safely performed. During this week one pint of saline with one ounce of glucose is administered per rectum every day. This is given three-quarters of an hour before the expected time of operation. In a nursing home, it is my custom to give it at 8.15 A.M.; in a hospital at 12.15 P.M.—the operation being performed at 9 A.M. or 1 P.M. respectively. If there be acute toxæmia or severe diarrhœa and vomiting, the glucose saline may be given intravenously. In the stage of thyroid crisis, Lahey advocates that a 5 per cent. solution of glucose be given continuously intravenously at the rate of 40–60 minims per minute, the Lugol's iodine being given with it in the proportion of 50 minims to 1,000 c.c. of fluid. If there be marked cardiac changes, more prolonged medical treatment may be required. The routine use of such a course of medical treatment is essential. It will greatly diminish the risk of operation, it will decrease, if not abolish, the necessity for preliminary ligature of vessels, and it will prevent the possibility of operating during an acute exacerbation of the disease.

Choice of anæsthetic.—It is generally agreed that the cause of the high operative mortality in the past was chloroform, alone or in a mixture. The question whether the operation should be carried out under a general or a local anæsthetic has given rise to much controversy. Dunhill and Kocher strongly advocated local anæsthesia, but the former now states that he has been using open ether with equally satisfactory results. Mayo advocates ether unless heart, kidney, lung, or tracheal complications be present, in which case he uses a local anæsthetic. Crile* administers open ether to avoid mental shock, and a local infiltration to block all paths of painful stimuli. It has been my experience that mental anxiety has a very serious effect on the result of the operation, and for this reason I have always used a general anæsthetic. If it is given in the ordinary way, even the passage to the theatre and the preliminaries to operation may give rise to marked nervous symptoms. To overcome this, the following is my routine: Three hours before operation 25 minims of Lugol's iodine is given, and, an hour before, a hypodermic injection of $\frac{1}{4}$ grain of morphia and $\frac{1}{100}$ grain of atropine. A quarter of an hour later the usual rectal saline injection is due, but on this day it is replaced by a mixture of olive oil and ether; the two drugs should be mixed in equal parts, and generally 6 oz. of the mixture is sufficient, but for a big woman or for a male, 7 oz. is necessary. This method, which was introduced by Gwathmey,† gives a very satisfactory anæsthesia. In about thirty minutes the patient passes through a slightly excitable stage and becomes unconscious. She is then wheeled to the theatre, and ether administered on an open mask. This must be given with caution, as absorption is still continuing from the rectum. As a general rule about 1 oz. is all that is required throughout the operation. Since these patients are very susceptible, only the minimum dose is given by rectum, and hence it is nearly always necessary to give a certain amount on the mask. Of late we have replaced this method by giving omnopon, $\frac{1}{3}$ grain, and scopolamin, $\frac{1}{150}$ grain, in the ward and continuing the anæsthesia with gas-and-oxygen. This is not only a much simpler method but the gas-and-oxygen appears to be less toxic than the ether. In the anæsthetic room the area of operation is infiltrated with 150–200 c.c. of a 0.25 per cent. solution of novocain with adrenalin added in the proportion of 1 in 200,000. This diminishes the hæmorrhage and probably prevents shock. No sterilization of the skin is undertaken until the patient is on the operating-table. A small sandbag having been placed under the shoulders, the skin is painted with iodine, and towels are stitched in position as in an operation for an adenoma (p. 1755).

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* *Lancet*, 1913, ii. 7.

† *Lancet*, 1913, ii. 1756.

Operative technique. (1) **Subtotal thyroidectomy.**—It is now universally recognized that in order to bring about a cure of the disease the greater part of the gland must be removed. In the earlier history of the operative treatment many surgeons removed too small a portion and the cure was either incomplete or a relapse occurred shortly afterwards, the remaining portion undergoing considerable hypertrophy. A small portion of the posterior surface of each lobe should alone be left, unless it be decided, in a severe case, to perform the operation in several stages.

A wide collar incision is made, reaching from $\frac{3}{4}$ in. external to the anterior border of the sterno-mastoid on the one side to a similar position on the other side. The flaps of skin are dissected upward and downward, and all superficial vessels clamped and tied. The sterno-mastoid muscles of each side are dissected from the underlying tissues and retracted. During this stage the sterno-mastoid branches of the superior thyroid arteries, which are often of considerable size, will be ligatured and divided. The anterior jugular veins are now seen as they lie in the space of Burns ; they are dissected free, and divided between ligatures. (Fig. 853.) These veins show considerable variation, but are usually two in number, with an intercommunicating branch. The pretracheal muscles, sterno-hyoid, sterno-thyroid, and omo-hyoid, covered by a layer of platysma, are divided in one sheet as they cross the isthmus of the thyroid, and are carefully dissected upward and downward from the anterior aspect of the gland. (Fig. 854.) It is at this stage that the dissection must be carefully carried out, for the muscles lie adjacent to the thin-walled superficial veins of the thyroid, which are very easily punctured and then bleed very freely. At the upper pole of the lateral lobe of the gland one or more branches of the superior thyroid artery may perforate the fibres of the sterno-thyroid muscle, and if so must be carefully freed. The pretracheal muscles are pulled upward with a retractor and each lobe in turn is gently depressed downward with a gauze pad. By this means the superior thyroid vessels are exposed and can be divided between ligatures. The ligatures, which are of silk, are passed above the level of the branch which runs transversely across the upper border of the isthmus, and both artery and vein are tied with the same ligature.

Both middle and both inferior veins are in the same way dissected free and divided between ligatures. The right sterno-mastoid muscle and carotid sheath are now retracted outward, and the right lobe of the

Fig. 854.—Subtotal thyroidectomy : pre-tracheal muscles divided and reflected in one sheet ; vessels of right superior pole ligatured and divided.

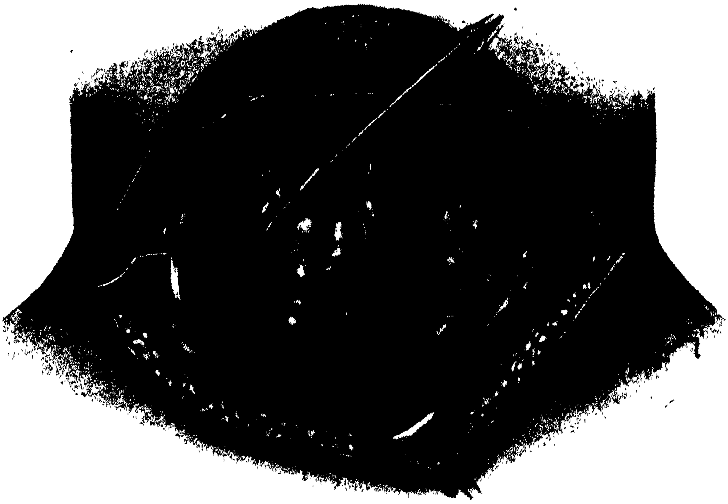

Fig. 855.—Subtotal thyroidectomy. Ligature of right inferior thyroid artery.

thyroid is gently pulled inward. Gentle dissection internal to the carotid sheath will expose the inferior thyroid artery as it lies on the longus colli muscle. (Fig. 855.) In this position it forms a loop before it passes downward and inward to the thyroid gland. The loop lies well to the outer side of the recurrent laryngeal nerve, which is not seen. Here it is ligatured but not divided. The left inferior thyroid artery is treated in a similar way. Both lateral lobes can now be gently dislocated forward and their full extent determined.

Up to this point there has been, in spite of the great vascularity of these cases, practically no bleeding, for every vessel has been ligatured before being divided. The capsule of the gland is now incised on the posterior surface, and a small portion of the gland cut off and left behind as the lateral lobe is turned inward. That is to say, the whole lobe is removed, except for a small portion, the size of a filbert nut, on the posterior surface. When the isthmus is reached, the incision is deepened until the trachea is seen, and the separation is continued inward at this level. (Fig. 856.) It is remarkable how free is the hæmorrhage from this cut posterior surface, although the inferior thyroid artery has been ligatured. The isthmus is now freed from the trachea and the left lobe treated in a similar way. All bleeding-points are carefully clamped and tied with fine silk which grips the friable tissue well. If possible the cut surface should not be oversewn but allowed to secrete freely into the wound. (Fig. 857.) When the wound is quite dry the sand-bag is removed, the pretracheal muscles are sutured with interrupted catgut, a small tube is placed down to the trachea, and the skin and platysma are sutured with fine silk. (Fig. 858.)

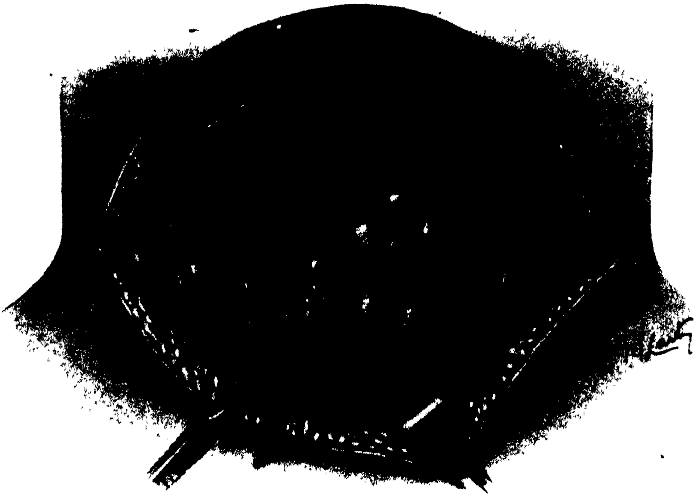

Fig. 856.—Subtotal thyroidectomy : resection of right lobe.

2. **Multiple stage operations.**—In advanced and neglected cases many surgeons advocate removal of the gland in several stages, perhaps after a preliminary ligature of vessels. With the more general recognition of the value of surgery and the modern methods of preparation the necessity for this is becoming less frequent, but cases

are still seen in which it is wise. At the first step the incision should be limited to one side of the neck, the sterno-mastoid of that side alone being retracted and only the pretracheal muscles of the one side being

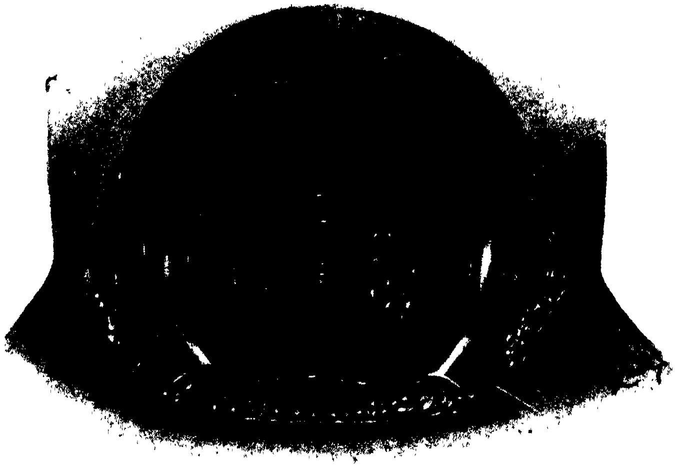

Fig. 857.—Subtotal thyroidectomy : portion of thyroid left after resection practice there would be rather less than is shown.

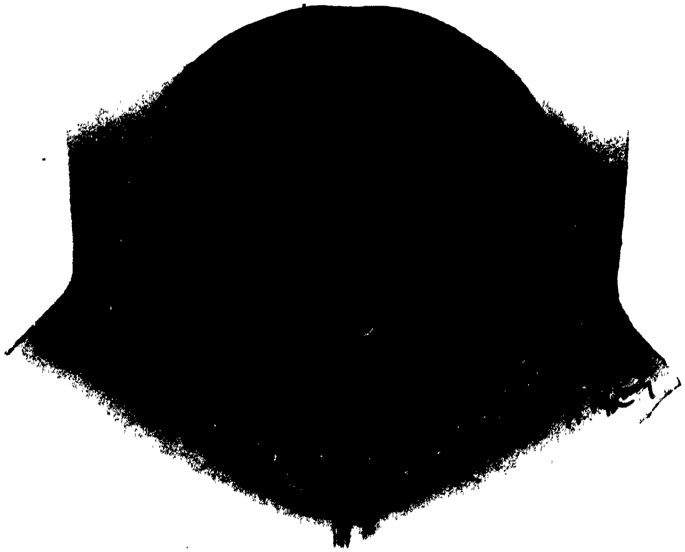

Fig. 858.—Subtotal thyroidectomy : muscles sutured ; tube inserted.

divided. The vessels of one lobe alone are ligatured and divided, and the greater part of this lobe and half or three-quarters of the isthmus are removed. Careful medical after-treatment is carried out, and the operation on the remaining portion is performed in about six weeks' time. The drawbacks of this method are the length of time consumed and the slightly increased difficulty of the second operation owing to adhesions, but in very severe cases a good result may be obtained where a subtotal removal would have been fatal.

(3) **Preliminary ligature of arteries.**—This operation was originally advocated by Halsted[*] as a preliminary step in severe cases, where partial thyroidectomy is likely to be associated with considerable danger. In the more severe cases, Halsted states that ligation of two, three, or even four arteries is never enough to cure, but may lead to sufficient improvement to allow hemithyroidectomy with safety at a later date. It must, however, be remembered, as Kocher has pointed out, that this operation is often followed by a reaction as severe as that after thyroidectomy. Lahey[†] strongly supports its use as a preliminary measure in severe and neglected cases.

Either the inferior or the superior artery may be ligatured. Halsted prefers the former, because the cosmetic effect is better, and the artery is generally the larger. Mayo and Berry[‡] prefer to tie the superior artery, as it is so much more accessible.

(*a*) *Ligature of the inferior thyroid artery.*—A transverse incision 1½–2 in. in length is made over the tendon of the omo-hyoid muscle in the line of the Kocher collar incision. The fibres of the sterno-mastoid muscle are separated in the line of the common carotid artery at the level of the omo-hyoid tendon. The thyroid lobe is exposed behind the posterior fibres of the sterno-thyroid muscle, and drawn inward by a retractor designed for this purpose. The common carotid artery is retracted outward, and the layers of fascia covering the inferior thyroid artery are divided at the level of the omo-hyoid tendon. The dissection is then carried out solely with two long, delicate, blunt dissectors. A special aneurysm-needle is used for carrying the fine silk ligature around the artery. The wound is sutured without drainage.

(*b*) *Ligature of the superior thyroid artery.*—An oblique incision is made crossing the upper pole of the lateral lobe of the thyroid. It runs from the centre of the thyroid cartilage upward and outward for about an inch. The fibres of the platysma muscle are divided in the line of the incision, and beneath will be found the omo-hyoid muscle. On the outer border of this muscle the upper pole of the lateral lobe will be seen, with the vessels attached to it. It is usually advocated that the vessels be not isolated but be ligatured *en masse.* The platysma may be sutured with a few catgut sutures and the skin closed with silkworm-gut.

(4) **Radiation.**—The value of treatment with X-rays or radium has been much debated, but my own experience has been unsatisfactory. It is true that naturally I am more likely to see the failures than the

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[*] *Ann. Surg.*, Aug., 1913, lviii, 178.

[†] *Surg. Gynæ. and Obstet.*, Feb. 1937, lxiv, 304.

[‡] *Brit. Journ. Surg.*, 1913, i, 699.

successes, but the early cases which I have transferred for such treatment have been benefited but little, if at all. Moreover, several cases have come to me for surgical treatment after this method has been used and have shown severe burns and scarring, very disfiguring telangiectases and in two cases localized epitheliomata of the overlying skin. The supporters of this method would claim that such are only the results of very badly applied treatment, but nevertheless they are dangers to be considered. For these reasons I do not advocate either radium or X-ray therapy.

After-treatment.—After any operation for this disease there is always some increase in the hyperthyroidism. The temperature and pulse are both raised for two or three days. This is the dangerous period, and steps must be taken to reduce the toxæmia as far as possible. The first essential is to maintain the drainage of the wound. The patient should be nursed in the sitting position. As long as the tube is in place, any thyroid secretion which is pouring out from the cut surfaces can readily escape. It should, therefore, never be removed until the temperature has been normal for at least twenty-four hours. If rectal ether has been given, a rectal wash should be administered as soon as the patient is returned to bed. In every case rectal injections of one pint of saline with one ounce of glucose should be repeated every twelve hours for five or six days, as they will do much to diminish the toxæmia. If given with care they will always be retained, and only in severe cases is it necessary to replace them with intravenous injections.

The patient must be kept as quiet as possible, and free from any surrounding disturbance. Hospital cases should always be screened off from the rest of the ward for the first two or three days. Morphia may be freely given ; in the first few days the patient is often very restless, and may require considerable doses to control her. In such circumstances a hypodermic injection of ¼ grain should be given, and repeated in two hours if necessary. In severe cases it is sometimes necessary to give as much as 2 grains in all in the first twenty-four hours, and there should be no hesitation in proceeding to this dose if the restlessness is not controlled. When there is marked postoperative hyperthyroidism it is customary to give Lugol's iodine in 15 min. doses four-hourly, although many claim that it is useless after the thyroid has been removed. As soon as the temperature has fallen to normal, and the patient is quieter and sleeping comfortably, these methods may be gradually diminished, and twenty-four hours later the tube may be removed. The patient, throughout her stay in hospital, should be kept free from excitement and given a meatless diet. Stimulants, including tea or coffee, should be withheld, and it is better to boil the drinking-water. The patient should not be allowed out of bed until at least three weeks after the operation.

With the more extensive resections performed to-day, the danger of postoperative tetany must always be kept in mind. When the operation is so planned that the posterior part of each lobe is left behind this danger is reduced to a minimum. In my own series of 554 cases there have only been three with transient tetany, which soon yielded to medical treatment. As has already been mentioned, the position and number of the parathyroids is subject to considerable variation, and therefore it is always possible that they may be injured. In some cases the characteristic symptoms of stiffness or contraction of the hands, feet, or limbs will commence within a few days of the operation; in others it may be delayed for several weeks. Richter and Zimmerman have shown that not uncommonly there may be no symptoms but there is latent tetany as shown by the presence of Trousseau's, Chvostek's and Erb's signs. At the earliest appearance of such signs the patient should be placed on a diet rich in calcium, given calcium lactate by mouth and parathyroid extract intramuscularly.

Results.—The value of surgical treatment in cases of hyperthyroidism is now universally acknowledged. It has, however, become widely recognized that to obtain a complete cure a much more extensive resection must be performed than was at one time considered necessary. With the more careful preparation and selection of the suitable time for operation, the mortality has been greatly reduced, so that in the usual type of case it is almost negligible. The figures from the Mayo Clinic show a mortality of under 1 per cent. Lahey, in a series of 15,200 operations upon 18,000 cases, had a total mortality of 0.85 per cent. It must be understood, however, that such results are only obtained by a wide knowledge of the condition and by most meticulous care in every stage of the preparation and operative treatment. Advanced and serious cases are still seen in which the danger of operation is very much higher, and it is probable that the presence of a larger number of these cases accounts for the somewhat higher mortality in this country. Joll states that in his series of 795 cases the total mortality was 2.1 per cent. In my own series of 554 cases it was just over 4 per cent., but it is my custom to grant the help of operation in practically every case in spite of the severity of the symptoms.

The late results of operation are very satisfactory, between 80 and 90 per cent. being converted from a condition of invalidism to healthy individuals able to earn their own living and lead useful and happy lives. It must be remembered, however, that considerable care is necessary in the after-treatment. While in hospital or the nursing home these patients make very rapid improvement, but there is often some relapse after they return to their own homes, and several months' convalescence is often required before they are able to face the stress of ordinary life. The length of convalescence depends upon the amount of damage that has been done by the hyperthyroidism; if the heart and kidneys have been seriously affected before operation, the changes may be irremediable, so that the patient may remain a permanent invalid, but the progress of the disease will have been checked. It will also happen at times that a patient who is apparently cured may suffer a temporary relapse if subjected to some sudden severe shock or strain.

The risk of injury to the parathyroid bodies has already been mentioned. In addition, there is danger of injury to the recurrent laryngeal nerves. With the modern method of leaving the posterior surface of each lobe, this danger is reduced to a minimum and it is probable that in some of the cases the injury was caused by pressure of the enlarged thyroid but passed unnoticed before operation. In Joll's series a unilateral lesion was present in 0.75 per cent. of the cases, an experience very similar to my own, where there were 4 examples in the 554 cases.

Stress has often been laid on the danger of a later development of myxœdema, but this is a very rare complication in cases of true exophthalmic goitre, being more likely with adenoparenchymatous goitres. In my own series there were three cases of doubtful and incomplete hypothyroidism.

CARCINOMA OF THE THYROID

Indications for operation.—Carcinoma of the thyroid is said to be more common in areas of endemic goitre. In countries where goitre is sporadic it is relatively rare, forming only about 2.5 per cent. of all nodular goitres (Joll). It is more common in females than in males but not to so marked a degree as are other forms of goitre. In my own series of 33 cases, 23 were females. There are several pathological types, but these cannot be recognized before microscopic examination and even then the pathological varieties are not clear cut ; so much is this the case that some surgeons believe that 10 per cent. of the cases are sarcomatous. Ewing doubts if sarcoma ever occurs and holds that all cases are carcinomatous. Dunhill also states that sarcoma is due to the capacity of the thyroid epithelium to undergo metaplasia. Clinically three types may be recognized : (1) Carcinoma arising in a previous goitre, usually a single adenoma or an adenoparenchymatous goitre. The cells of the adenoma undergo proliferation and may give rise to some degree of hyperthyroidism ; in fact Plummer states that thyrotoxicosis occurring with an adenoma is a warning of the onset of carcinoma. In my own series this variety was seen in 14 of the 33 cases. (2) Carcinoma arising in a previously healthy gland. This may form a localized mass, at first limited to one lobe but tending later to spread to the rest of the gland, and associated with early secondary deposits in the lymphatic nodes. This is often a papillary type on section or it may form a harder, more irregular, diffuse mass tending to invade surrounding structures or to ulcerate externally or into the trachea, secondary lymphatic deposits only occurring at a later stage. These are more often of the scirrhous type. (3) A variety in which the primary lesion is small, and may, indeed, give no local physical signs, but is associated with one or more secondary deposits elsewhere. The areas most subject to these deposits are the long bones. In several such cases an amputation has been performed for what was regarded as a primary bone sarcoma, but pathological investigation has shown that the tumour was a secondary carcinoma of the thyroid. The primary focus in such cases is often of slow growth, as in a case reported by Sir Frederick Eve,* where the patient remained well except for a progressive enlargement of the thyroid for three years after the amputation. The secondary deposits in carcinoma of the thyroid are of interest in that they may function as thyroid tissue, and may prevent myxœdema after removal of the whole of the thyroid gland.

The prognosis with carcinoma of thyroid is always serious, but statistics show that it has been greatly improved within recent years by the careful use of operation and X-ray treatment. In advanced cases operation may be unsuccessful in removing the whole of the disease and may soon be followed by wide dissemination, but even in such cases X-ray treatment may be very helpful.

In deciding on operation, the following factors have to be considered : (1) *Dilated veins.*—A large number of greatly dilated veins over the surface of the tumour and in the surrounding areas, provided the patient is not suffering from hyperthyroidism or respiratory obstruction, will be evidence of greatly increased vascularity and generally of extensive growth. They are therefore a contra-indication to operative treatment. (2) *Wide involvement of muscles.*—If the surrounding muscles are widely involved, as shown by fixation of the growth and of the trachea, and by irregularity in the surface of the muscles, operative treatment is likely to be unsuccessful. An operation may, however, give satisfactory results with a slowly-growing tumour, even when there is some involvement of the surrounding muscles. In one of my cases it was necessary to remove a considerable amount of the pretracheal muscles, which were infiltrated, and yet no recurrence has followed after three years. (3) *Secondary deposits.*—With a primary carcinoma in any other portion of the body, perhaps with the exception of the kidneys and suprarenal gland, the presence of secondary deposits in remote areas is an absolute counter-indication to operative removal. This, however, is not necessarily so with the thyroid. A secondary deposit in a bone is sometimes found with a very slowly-growing tumour in the thyroid gland, so that it may be possible, if there be only one such deposit, to remove it by amputation or local resection, and then to excise the primary focus. Manifestly the prognosis will depend upon the condition of the thyroid gland. If this has already become inoperable, no surgical treatment should be performed upon the secondary deposit except for palliative reasons, but if it be small and freely movable, its eradication may be possible. Neither is the presence of secondary deposits in the surrounding lymphatic glands a clear indication against operative treatment. A slowly-growing localized tumour in one lobe of the thyroid may be associated with several enlarged movable glands, which can be resected with a good chance of a cure. Trotter* reported a case with multiple secondary deposits in the glands where the right half of the thyroid and the glands were removed and there was no recurrence after three and a half years. In one of my own cases the patient remained free of recurrence, after removal of a portion of the thyroid and involved glands, for four years, and death did not occur until a further three years after the appearance of secondary deposits. (4) *Evidence of local pressure.*—Pressure on the trachea is in itself no contra-indication to operation. Cases may be observed where a large adenoma has given rise to considerable pressure, and in one part, perhaps anteriorly, has undergone a slowly-growing carcinomatous change. The pressure is, however, due more to the adenomatous than to the carcinomatous element, and removal may be followed by complete cure. But if the local signs of malignancy are advanced, if there be a severe cough and expectoration of blood-stained sputum, it is probable that the trachea is being eroded rather than compressed by the growth, and no operation should be undertaken. While pressure on the recurrent laryngeal nerve is more likely with carcinoma, it may sometimes be seen with adenoma. Pressure on the surrounding vessels and on the œsophagus is more likely with a carcinoma than with a benign tumour, and therefore, if with such pressure there be a rapidly increasing growth which is involving the muscles, an operation is contra-indicated.

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* *Proc. Roy. Soc. Med.*, April, 1911, iv (Clin. Sect.), 118.

It may be said, then: (1) If the tumour be rapidly growing, if it be of large size with much surrounding dilatation of vessels, if the muscles be widely involved, and if there be evidence of invasion of the trachea, as shown by cough and blood-stained expectoration, no operation should be undertaken. (2) If there be secondary deposits in a bone or in the glands, operation should only be undertaken if the tumour of the thyroid be relatively small and slowly growing. (3) If the tumour be small and slowly growing, and the local signs of malignancy be not advanced, that is to say, if the muscles are only slightly involved and there be no evidence of involvement of the trachea, operation should be performed at the earliest opportunity, especially if these relatively slight changes are secondary to an adenoma of the thyroid.

Choice of operation.—If an adenoma localized to one lobe has undergone secondary carcinomatous changes, partial or hemithyroidectomy will be sufficient. Any of the surrounding muscles that may be adherent should be freely removed, and a good margin of the healthy thyroid tissue taken away with the growth. Even if the evidence of malignancy be slight and localized—if, for instance, the pretracheal muscles are only involved in a small area anteriorly—no attempt must be made to dissect out the deeper part of the adenoma. The whole of the lobe and a portion of the isthmus must be freely removed. If the thyroid contains several adenomatous masses, only one of which is clearly carcinomatous, or if the neoplasm be not well defined and has manifestly not commenced in an adenoma, the whole thyroid should unhesitatingly be removed. Such an operation is often condemned owing to the fact that the patient will develop post-operative myxœdema. But there can be no question whatever that the patient is far better off with myxœdema, which can be completely controlled with small doses of thyroid extract, than with a carcinomatous lesion which may rapidly become fatal.

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* *Proc. Roy. Soc. Med.*, April, 1911, iv, 118.

Preparation for operation.—The preparation for operation will be similar to that in adenoma (p. 1755). If, as not uncommonly happens, the tumour be associated with hyperthyroidism, it may be necessary to give a short course of preliminary treatment similar to that advocated in exophthalmic goitre. The preparation of the patient on the table will be similar to that for exophthalmic goitre. If there be hyperthyroidism, the anæsthetic should be administered as for a case of exophthalmic goitre. In other cases, ether by the open method will be found satisfactory.

Operative technique.—A wide collar incision should be made and the skin-flap reflected in the usual manner. The anterior jugular veins are ligatured and divided, and if the sterno-mastoids be uninvolved they are widely retracted. The pretracheal muscles must be carefully investigated ; if they be adherent to the thyroid, the portion involved is freely divided above and below this level, so that the involved section is removed with the thyroid gland. If the growth be limited to one side of the gland, the vessels of that lobe are ligatured and divided in order. If it be more diffuse and it be decided to remove the whole gland, the vessels of the opposite lobe are treated in a similar manner. The amount of gland to be resected is carefully separated and dissected off the trachea. If only one half be removed, the isthmus will be divided some ½ or ¾ in. beyond the margin of the growth. The lymphatic nodes of the lower jugular group should be removed if they are at all enlarged and in all cases where the growth has extended through the thyroid capsule. Lahey advocates that the internal jugular vein should be ligatured and excised. The pretracheal muscles are, as far as possible, sutured together with catgut. The cavity is drained by a small tube and the skin sutured in the usual manner.

X-ray treatment.—X-rays are most helpful and, in many cases, appear to be almost specific. So beneficial are they that this form of treatment may in the future replace surgery. In the present state of our knowledge, however, it should be reserved for advanced cases where operation is unsuitable and for recurrence after operation. It is also a valuable adjunct where an extensive operation has been undertaken and there is some doubt if the whole of the disease has been removed. In inoperable cases it should always be prescribed, for the primary growth will in most cases rapidly disappear and, although secondary deposits will generally occur elsewhere in the body after several months, the patient will be entirely relieved of the painful and distressing effects of the local growth. In my own experience X-ray treatment has been of much greater value than radium.

Results.—Few statistics of the results of these operations have been published, but all are agreed that the prognosis is much better with cases of malignant adenomata and papillary carcinoma ; in fact Lahey* states that these are the only types which, in his experience, have been cured by surgery, but fortunately they are the most common. Of 49 cases of malignant adenomata, 26 were alive and apparently free for 3 to 17 years after operation. At the end of 3 years 43 per cent. were alive and at the end of 5 years 35 per cent. Of 14 cases of papillary carcinoma, 64 per cent. were alive from 3 to 13 years after operation. On the other hand, Haas† states that true cancer of the thyroid can be cured, and that he had reported 11 cases free from recurrence after more than six years, but he does not think that any cases of malignant adenomata can really be cured. These conflicting opinions are probably due to different interpretations of the pathological picture, and since the different varieties can only be diagnosed after microscopical examination it is better to consider all types together. In my own series of 33 cases treatment was possible in 32 with the following results. There were twelve cases treated by operation only. Of these four died within a year, three have been lost sight of, and five are alive and well, one for two years, one for four years, one for five years and two for seven years after operation. Eight cases have been treated by X-rays for recurrence after operation ; of these five died, three one year, one two years and one seven years after treatment. Three are alive and well, one three years, one five years, and one eleven years after treatment. Nine cases have been treated by X-rays only. Seven died within a year. Two are alive and well, one two years and one three years after treatment. Three cases were treated by palliative measures only ; all died within a year.

GRAFTING FOR HYPOTHYROIDISM

Indications for operation.—In England only sporadic cretinism is seen. In such cases there is no family history, the cretinism is generally severe, and the thyroid is usually atrophic. In endemic countries there is often a family history of goitre, there are milder cases and the condition is frequently associated with a goitre. Both groups of cases are greatly improved by medical treatment. In a few cases the thyroid gland may to a certain extent regain its function and the same is true with idiopathic myxœdema. For this reason medical treatment should be continued for a long period. An operation may be required to relieve pressure symptoms when a goitre is present, but should not be performed to relieve the cretinism.

Sometimes the whole thyroid has been removed for carcinoma, or occasionally an aberrant thyroid has been mistaken for a tumour. Stress must here be laid upon the fact that no cyst or tumour in the line of the thyro-glossal duct should ever be operated upon until it is certain that there is a normal portion of thyroid present. These patients will have to be supplied with thyroid secretion throughout the whole of their lives, and since even the administration of small tablets of thyroid extract becomes irksome, attempts have been made to graft a portion of growing thyroid. How far this may be expected to be successful is still uncertain, for it is a curious fact that, although experimentally tissue may be made to grow in homogeneous plasma outside the body, the most successful operations within the body have been those where autogenous grafts of bone, fascia, or other tissues have been used. Since in these cases of cretinism there is no thyroid tissue to take from the patient's own body, the outlook is less satisfactory, but as the operation is not dangerous to the patient and its value is still uncertain, it must be regarded as justifiable in the conditions mentioned.

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* *Surg. Gynæc. and Obstet.*, 1937, lxiv, No. 5, 927.

† *Lancet*, May 15, 1937, i, 1155.

Operative technique.—It is preferable that the two patients be operated upon by separate surgeons working in the same theatre. The graft should always be taken from a thyroid which is as healthy as possible, as it is still somewhat uncertain whether the secretion of a pathological gland is normal. A patient should be selected who has an adenoma of the thyroid, for when the adenoma is shelled out a small portion of the surrounding normal tissue may be excised for the purposes of grafting. It has been thought that the unsuccessful results which so often follow depend on the fact that the graft does not become vascularized rapidly, and great stress has been laid upon the position in which it is placed. It is believed that the more vascular the bed, the more likely it is to grow. Bircher* transplanted portions into the cervical subcutaneous tissue. Payr successfully grafted a portion into the spleen, while Kocher advocated that the graft should be placed in the cancellous medulla at the ends of the long bones. Other sites that have been chosen are the extraperitoneal area, the perirenal tissue, or close to the internal mammary artery. Whatever be the site chosen, it should be laid bare in the early stage of the operation on the donor, and all hæmorrhage carefully controlled by pressure before the graft is inserted. If there be a large amount of blood around the graft, it is almost certain to be destroyed. It is important that before it is placed *in situ* it be cut into small portions, for the central areas of large pieces of tissue growing in plasma outside the body always die. The bed should be carefully closed, and the wound sutured without drainage.

Results.—Most of the published results have been unsatisfactory. Voronoff† has claimed successful results lasting for twenty years. He uses either the thyroid of the patient's mother or that of apes, and lays stress on the importance of inserting the graft in the normal site of the thyroid. Most observers have, however, failed entirely to obtain benefit by grafting from a different species. In nearly all the other operations reported, the results have been satisfactory for a time, but later have proved inefficient. The benefits seem to be due to absorption of the thyroid secretion from the graft, and cease as soon as this secretion is absorbed. The operation is, therefore, still in the experimental stage.

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* Zentralbl. f. Chir. No. 5, 1912, xxxix, 138.
† Rev. de Path. Comp. Oct. 1937, No. 492, xxxvii, 1133.

OPERATIONS ON THE PARATHYROID GLANDS

Hyperparathyroidism.—An adenoma, or possibly a simple hypertrophy of one or more of the parathyroid glands, may give rise to increased calcium metabolism, as shown by a rise in the serum calcium and in the output of calcium in the urine and fæces. Clinically this is shown by a generalized osteitis fibrosa, the bones becoming decalcified, bent and easily fractured, and developing trabeculated cyst-like areas. At the same time the increased secretion of calcium may lead to the formation of renal calculi. A full account of these changes has been given by Hunter.‡ In such cases the tumour of the parathyroid ought to be removed.

The thyroid gland must be fully exposed by a collar incision and free division of the pretracheal muscles. A most thorough and careful search must then be made for the parathyroid tumour. This may be found in one of the normal parathyroid positions. In my own series of 14 cases, one of the inferior bodies was usually affected; only one tumour arising from a superior body, but Sir T. Dunhill states that in his series the superior body was most frequently affected. Tumours may, however, be found in unusual situations which are probably due to abnormalities in development. Thus, they may be found in close relationship with the pericardium, as in a case reported by Gordon-Taylor, which necessitated splitting the sternum and exploring the mediastinum. It is also possible for such a tumour to develop in the substance of the thyroid gland. The important relationship to the thyroid fascia has been described in the anatomical section (p. 1747). If in front of this fascia, the tumour may, as it enlarges, pass downwards behind the sternum into the superior mediastinum. If, however, it lies behind the fascia it will pass down, as it enlarges, behind the œsophagus and come to lie in the concavity of the curve of the upper dorsal vertebræ.

After complete exposure of the thyroid gland a methodical search should be made in all the possible positions of such a tumour. (Fig. 859.) Each lobe being turned inward, the sites of the superior bodies are easily examined. The lower poles are then turned inward and upward and the normal sites of the inferior bodies explored. If no tumour is found, a finger may be inserted down behind the sternum on each side, as for the examination of a retrosternal goitre. If no tumour still be found, the right lobe should be turned inward and the thyroid fascia divided above the inferior thyroid artery. (Fig. 860.) A finger can now be inserted down on to the longus colli muscle and along into the thorax. By this means a tumour may be felt in the concavity of the dorsal vertebræ behind the œsophagus. In three of my cases the tumour occupied this position behind the fascia. In one the tumour, which was as large as a plum, was entirely in the concavity of a dorsal vertebra but was easily freed with the finger and dislocated up into the neck. All such tumours are easily freed and can be removed after ligature of their pedicles. Care should be taken not to injure the normal parathyroids, as this will increase the risk of post-operative tetany. If no tumour be found in one of these positions and one be felt within one lobe of the thyroid, this should be removed, but it usually proves to be only an adenoma of the thyroid gland. The sternum should only be split if no tumour be found in the above sites, but there is positive evidence from the blood and urine examinations that a tumour is present. When the tumour has been removed a small drainage-tube should be inserted, the muscles sutured, and the wound closed.

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‡ *Proc. Roy. Soc. Med.*, 1929, xxiii, 227.

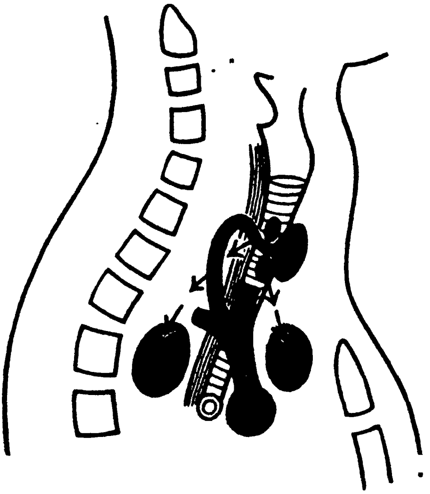

Fig. 859.—Alternative positions of the inferior parathyroid bodies and their tumours.

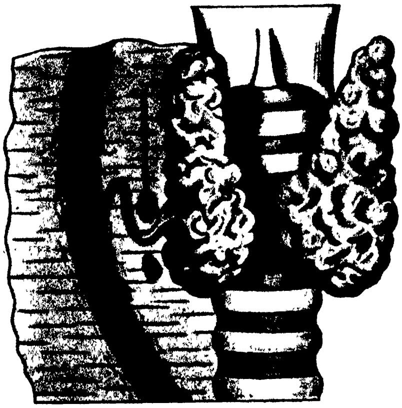

Fig. 860.—Incision in thyroid fascia to expose a tumour of a deeply-situated inferior parathyroid. (In this diagram the inferior thyroid wrongly seems to arise from the common carotid artery, which should be shown in front of the fascia.)

After operation a temporary tetany may occur, but it is usually easily controlled by the administration of calcium and parathormone.

Hypoparathyroidism.—In certain cases an operation on the thyroid gland may be followed by tetany, indicating that the parathyroid secretion has been reduced or eliminated. The modern methods of operating are specially devised so as to subject these glands to as little danger as possible, and thus, as a rule, only one parathyroid at most is injured and the tetany is therefore only temporary. It can then be cured by the administration of calcium and parathormone. In permanent cases, where probably all the parathyroid tissue has been removed, the symptoms may often be controlled by similar measures, but they have to be permanently employed, a method of treatment which is somewhat uncertain and is always irksome to the patient. Therefore, attempts have been made to produce a permanent cure by parathyroid transplantation. The difficulties here are similar to those encountered with the thyroid gland. In the majority of reported cases the transplant has died and only temporary relief has been obtained. The chief cause of failure appears to be due to the fact that a homogeneous transplant has to be used, and thus, if a parathyroid be recognized on the removed thyroid, it ought to be immediately transplanted into the sterno-mastoid muscle (autogenous graft). A few cases of doubtfully successful homogeneous grafting have been reported, the gland in these cases having been grafted into the rectus abdominis muscle. A full account of the reported cases and of the difficulties is given by Cattell.*

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* *Amer. Jour. Surg.*, 1, July, 1929, vii, 4.

CHAPTER XXXIX

SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM

By GEOFFREY JEFFERSON, C.B.E.

Introductory.—Scarcely less important than the discovery of the motor area has been the accumulation during recent years of knowledge of the central hypothalamic nuclei which control autonomic action, centres which are in part under nervous, in large part under hormonal and biochemical influence. Centres for the control of body temperature, sweating, vaso-motor tone and blood-pressure, cardiac rate, respiration, gastric motility and secretion and bladder tonus have been in some degree delineated. From them pathways descend through the brain-stem to the lateral cell columns in the spinal cord, to emerge as pre-ganglionic fibres by the white rami, and to proceed to their destinations in the limbs, adrenals, liver, intestines, pelvic viscera, and so forth. The system is intimately bound up with, and is very sensitive to, hormonal influences. It acts conservatively, often defensively, diffusely ; it adjusts the organism to the difficult problems which it must solve in order to survive. It has none of the superbly local and precise action that characterizes the central nervous system proper. Yet it is, in a different way, highly integrated. The surgery of the sympathetic nervous system is concerned only with the peripheral divisions, and its results are frequently conditioned for good or ill by the non-nervous factors which are ordinarily the system's most potent motivators. The effects of these moderating influences will be described here and there in the following pages, in which the more standardized of the possible interventions on the sympathetic nervous system are set forth.

SURGERY OF RAYNAUD'S PHENOMENON AND VASO-SPASTIC CONDITIONS

The large number of sympathetic denervations carried out in the early years after the publication of the work of Hunter and Royle on muscle hyper-tonus led to the discovery of certain facts of greater usefulness and practicability. It was noted that, although spasticity was usually not lessened, the limbs operated upon were warmer and pinker than had been their wont and, further, that this increase in temperature was sustained. It was but a short step to apply this operation directly to the treatment of vaso-spasm, and it may be said that sympathectomy finds here its greatest field of usefulness. It is, however, essential to select cases with caution if good results are to be obtained, and careful observations are required to rule out those in which the anæmia is due to vascular obstruction. Only thus can cases be correctly graded and selected. In the absence of wise selection the operation may fail because a patient's arteries are incapable of dilatation.

Innervation of the blood-vessels.—It was once believed that the vaso-motor nerves ran from the peri-aortic plexus to the vessels of the limbs in a continuous sheet without further reinforcement. The work of Todd, of Kramer and Todd (1916), and of Potts (1916) (inspired by Todd) indicated that only the most proximal portions of the great vessels of the limbs receive their innervation in this way, and that the greater part is carried to the arteries by the peripheral nerves at many points along the length of the vessels. This conception has been proved to be well founded by the later observations of Kuntz and Levy, of Blair, Duff and Bingham, and more particularly of Woollard ; the subject has been admirably reviewed by White and Smithwick (1941). The reinforcing strands, derived from the non-medullated fibres which have long been recognized in the peripheral nerves, supply the chief vaso-constrictor control to the arteries, arterioles, sweat-glands and hairs. The fibres are given off from the main nerve-trunks at various levels as far as the extremity of the limb, but seem to come off at certain elective points. The femoral artery receives branches from the anterior crural, lower down from the obturator, in the upper part of the popliteal space from the sciatic ; the posterior tibial artery obtains a rich supply, according to Potts, from the tibial nerve, and so the sympathetic twigs come seriatim down to the digital vessels themselves. We know that these fibres from the peripheral nerves are largely, if not entirely, constrictor, because complete section of the peripheral nerve, or physiological nerve-trunk block high in the limb, causes dilatation of the vessels and absence of sweating in an area corresponding roughly with the resulting anæsthesia (Lewis). The sympathetic fibres form a continuous plexus in the muscular coat of the arteries and arterioles, reinforced but not interrupted by the peripheral fibres joining the perivascular sheath. It is clear that removal of a segment of sheath at the root of a limb can only interfere with the vaso-motor outflow for a very limited distance, and cannot interrupt the efferent impulses which enter the artery at a lower level and constitute its chief supply. It is true that periarterial neurectomy has at times brought about a satisfactory result. But it has been established that the vaso-dilatation induced by periarterial stripping reaches a maximum in four days, after which there is a gradual decline to the pre-existing level, until at the end of five weeks, at most, no increase in the blood-flow to the limb can be detected (Lambert Rogers, Kobayashi).

This means that the operation could benefit only rapidly curable lesions, and it has almost gone out of use. At the present day periarterial sympathectomy can be recommended only in one place : for the denervation of the carotid sinus. The operation is then performed not to cause vaso-dilatation but to cure the "carotid sinus syndrome" which consists in syncopal or pseudo-epileptic attacks when pressure is made on the sinus, as by turning the heador the pressure of a collar. The operation needs no special description, for the steps are identical with those in preparation of the carotid bifurcation for ligature with only this addition, that the adventitia is carefully cleaned of nerve strands for 2 cm. above and below and that the tissue is removed. The injection of novocain into the adventitial coat helps to make the tissue more apparent by lifting it up and has the further advantage of preventing reflex syncope whilst the sinus dissection is in progress.

Physiology of vaso-constriction.—The four limbs comprise 65 per cent. of the body surface, and by regulation of their vessels the greater part of heat storage and loss is effected. As has been said, the impulses pass from the hypothalamus to cells in the intermedio-lateral column of the grey matter of the spinal cord, and run by pre-ganglionic white rami from the anterior roots .to the paravertebral chains of ganglia. From these ganglia fibres pass to the limb and visceral vascular trees either (*a*) as direct post-ganglionic fibres or (*b*) by joining the main peripheral nerve-trunks or their plexuses as gray rami and being carried in them towards the periphery. There is evidence that vaso-dilators also exist, with cell stations in the posterior spinal root-ganglia. Thence they run as fine non-medullated fibres in the posterior roots to join the peripheral nerves. Stimulation of the distal end of a cut posterior root causes an area of flushing of the skin in the segment proper to it, a fact used by Foerster in identifying spinal roots at operation. The activities of the vaso-dilators are much less obvious than those of the vaso-constrictors. Vaso-constriction, like all sympathetic activities, occurs as a diffuse action and can be produced by many chemical and hormonal agents as well as by the natural stimulations of cold, fear and emotion—in the last, to be sure, the liberation of adrenalin plays the most important part.

Indications for operation.—Sympathectomy should naturally prove most beneficial in cases where spasm of otherwise normal vessels is the essential feature. This condition is pre-eminently realized in early Raynaud's disease (or " Raynaud's phenomenon," to use a term coming into use). In later stages fibrotic changes occur in the vessels and in the soft tissues, leading to sclerodermia, ulceration and local gangrene; when these alterations have occurred operation, though not to be prohibited completely, cannot be expected to give great or lasting relief. When sclerodermatous changes are advanced, a cervical sympathectomy, which stops sweat secretion as well as vaso-constriction, may be disadvantageous because the hands lack moisture. But in early cases of Raynaud's disease the lack of sweat secretion is no drawback and, particularly in its newer forms, sympathectomy is a thoroughly worth-while procedure. It is not yet known how early in Raynaud's disease anatomical alterations take place in the vessels. Lewis, on the ground of most painstaking studies, thinks that they must take place very soon, especially in the upper limb, for he finds that the vessels usually behave abnormally even after sympathectomy. This has led him to challenge the view that the Raynaud disease is essentially a nervous disease, as its discoverer and his followers contended. Lewis holds that the vaso-spastic attacks are caused by minute intramural changes in the smallest arteries, and that the spasm is due to diseased walls rather than to the outflow of nervous influences. Against this view is the fact that emotion can often precipitate attacks, while increased sweating very commonly accompanies the vaso-spasm ; both these facts favour the theory of central sympathetic discharge. Sympathectomy, which cuts constrictor fibres, cures a number and benefits the majority of these patients. The causes of failure or of recurrence will be discussed later (p. 1805) ; changes in the structure of the vessel walls must be considered in evaluating failure.

CHRONIC ARTERIAL OBSTRUCTION AND SPASM

Sympathetic denervation finds a more limited field of usefulness in certain cases of chronic arterial obstruction, notably thrombo-angiitis obliterans (Buerger's disease). The hopes that this disease might be arrested by an early sympathectomy have not been completely fulfilled, though some surgeons have published very encouraging figures. Sympathectomy has no effect on the disease process itself ; it causes dilatation of all available permeable vessels, thus helping the collateral circulation, and putting off the day when amputation may be necessary. The affection is not uncommon in young adults and may be mistaken for Raynaud's disease. The latter is almost confined to females, while thrombo-angiitis, though it attacks both sexes, is seen predominantly in males. The pathology of the condition is by no means fully known. Small areas of intimal inflammation arise, leading to local thrombosis and final organization of the clot, which may or may not be canalized. The chief clinical features are :—Repetition of these events ; the chance as to whether large or small vessels are affected ; a variable frequency ; the degree of canalization, allowing a sufficiently free, or ending in a grossly impaired, acral circulation. These variations account for the differences presented by individual cases. The lower extremities are first affected, but similar changes may later on overtake the upper limbs. In general, the disease progresses, and some 25 per cent. of the untreated cases come to amputation, some while still under 30 years of age, others not until a decade or so later. A similar affection of the coronary vessels tends to shorten the lives of these sufferers and to add to the risks of operation in later life ; cerebral or mesenteric thrombosis may be a cause of death. At operation on the sympathetic ganglia in this condition, as in Raynaud's disease, a considerable degree of inflammatory change has often been noticed in the retroperitoneal tissues and in the posterior mediastinum. Variations in the thickness of the sympathetic chains, abnormal swelling of these chains, and vacuolization of the ganglion cells have been found on histological study. But Craig and Kernohan, in a study of material from 208 cases at the Mayo Clinic, find that these changes are not sufficiently constant to allow the firm conclusion that the cell alterations are primary, and vascular spasm and occlusion secondary. Changes of a similar kind may often be observed in specimens from control material.

Ganglionectomy retards the date of high amputation. The most hopeful figures are those of Brown, Craig, and Kernohan, who found that only 5, instead of 25, per cent. of cases required amputation during the period over which they had been studied. Learmonth has classified the clinical types as follows :

(1) An early group, usually (and wrongly) labelled Raynaud's disease in the male.
(2) A group in which the disease is very slowly progressive, so slowly that it may appear to reach a stationary condition.
(3) A group in which progress is episodic, corresponding to clearly recognizable attacks of thrombosis.
(4) A group in which the disease passes rapidly to massive gangrene.

Indications for operation.—The indication for sympathectomy is clear if the vascular occlusion is only partial and if a sufficient collateral vascular stream can be released to flood the periphery once more. But if the main vessels rather than the subsidiary ones are blocked by post-thrombotic fibrosis, nothing can be hoped for from sympathectomy. The surgeon will often be asked to see cases so bad that they are fit only for amputation ; to perform sympathectomy on such cases can only bring the operation into disrepute.

The singular suitability of Raynaud's disease and thrombo-angiitis obliterans above all others lies in the fact that in the one there are no important changes in the vessel wall in the milder cases, and that in the other the changes are patchy. Thrombo-angiitic cases should be operated upon as early as possible after the establishment of the disease, and it may be doubted whether the palliative measures (acetylcholine, protein shock, postural manœuvres, radiant heat) which sometimes succeed in tiding a patient over an individual attack of thrombo-angiitis, are not actually a disservice since they are so often the means of postponing a useful operation.

There are few indications for operation in vascular diseases other than these. Rarely a case of endarteritis obliterans (when not diabetic) may prove on study to be suitable. Frank arterio-sclerosis with failing circulation, with or without calcification in the vessel walls, is not likely to be relieved by sympathectomy, however greatly the surgeon may wish to avoid an amputation. But in all types of incomplete arterial obstruction careful study will sometimes reveal a suitable case.

Tests for vascular occlusion and vaso-motor release.—The surgeon knows well that the subjects of Raynaud's disease will be so much improved by operation that no special pre-operative study is required, provided always that the case is not of such severity that sclerosis has supervened. None the less, the Raynaud cases furnish excellent material for observation, and no one entering his novitiate in this work should neglect them, however certain he may be in his own mind of the expectations of the case. Conversely, he will know well that a man of fifty, with a thirty-year history of thrombo-angiitis obliterans, for which several amputations have already been undergone, will have acquired vessels of such a nature that no nervous release can benefit them. Between these extremes are many patients who are aware that the failing circulation of their feet, or legs, or hands, bids fair to cut short their working days. Correct selection, on which alone depends success or disappointment, can only be achieved by the application of discriminatory tests.

Angiography by the injection of sodium iodide or thorotrast is not of much service. For what the surgeon wants to know is not whether the width of the branches of the arterial tree is greatly diminished, but whether the narrowing, already known on clinical grounds to be present, is capable of relaxation and whether unaffected vessels can be dilated. Novocain produces physiological paralysis of sympathetic fibres, durable enough for accurate observations on the effect of throwing these nerves out of action. (These and other tests will be described on p. 1795.) The general clinical examination informs the surgeon of pulsation at the wrist and ankle, the most favourable cases being those in which the beat of the larger vessels is still distinctly palpable, even though it may be reduced. The Pachon oscillometer records pulsations not recognizable on palpation. Examination of the limbs by X-rays may demonstrate calcification in the arteries, a most unfavourable finding, for the surgeon who garners his chief material in this type of case and in those with pulses absent high in the limb will have disheartening experiences to balance his rare success. The best that he may discover is that, although he fails to improve the peripheral circulation, in some cases there is a lessening of the pain which is so common and so distressing a feature. Pre-operative tests with paravertebral block will help to select the individuals who may be, in this respect, relieved.

Investigation for suspected vascular occlusion.—Under this heading come those general clinical observations which the well-trained surgeon must never omit. These include general inspection of the limb, and notes on the colour of the feet and hands, evidence of old or present ulcerations and local gangrenes, pulsations over the arterial tree and any absence of pulsation, and the effects of exercise, which generally increases pain. The effects of heat may be tried, but surface appearances are deceptive because flushing is due to local arteriolar and capillary relaxation and gives no useful evidence of the state of the deep vessels at any point. According to Lewis, colour is due to the state of the skin capillaries, pink if relaxed, blue when the speed of flow is retarded ; skin temperature, on the other hand, is determined by the relaxation or otherwise of the arterioles. Elevation of the limb gives useful information, for, while the normal limb retains its colour when elevated 180°, cadaveric pallor appears at 135° or thereabouts in patients with vascular obstruction. On the other hand, a case in which there is failure of the colour to return when the limb is lowered by successive stages to 70° has a badly compromised circulation (Buerger).

These tests give information on the quality and quantity of the circulation in the limb. If no pulse can be felt at the ankle, for instance, the oscillometer may show that a fair volume of blood is still passing, while the results of the postural tests may indicate at what level the circulation is failing.

Special tests for vascular occlusion.—**Sympathetic block by local anæsthesia.**—It has long been known that accidental division of the main nerve-trunks produces sympathetic paralysis as well as the more obvious sensory and motor palsies. Lewis in 1929 was the first to study peripheral vascular release by inducing physiological paralysis by novocaining nerve trunks. He injected the ulnar nerve behind the elbow with 2 per cent. novocain ; in a few minutes the ulnar border of the hand and the little finger became bright pink and the surface temperature rose very greatly. This observation is one of fundamental interest and importance, for it proves the rightness of anatomical teaching that the vaso-constrictor fibres run bound up in the peripheral nerve-trunks, leaving them at intervals to reach the arteries as they course down the limbs. At the same time the reason for the comparative failure of peri-arterial sympathectomy at the root of a limb becomes apparent, because a large number of important vaso-motor fibres, not yet having reached the artery at so high a level as the point of denudation, must escape severance. J. C. White (1934) pointed out that it may be necessary to anæsthetize both the ulnar and median nerve at the elbow or wrist to obtain full relaxation in the little finger. Peripheral nerve-blocks of this kind, either for the hand or foot, are good methods of testing vaso-dilatation. Wider areas are affected by either spinal or paravertebral anæsthesia. With both of these manœuvres, normal persons show a profound sympathetic release with consequent rise in peripheral limb temperature, provided that a sufficiently wide area is brought under control. When, in circulatory deficiency (from whatever cause), a considerable elevation above that previously existing results from the application of these test-conditions, and more especially when the released vessels cause the skin temperature to approximate to normal, absolutely certain benefit can be predicted as the result of operation. Splanchnic block is free from the fallacy of falls in temperature due to fall in blood-pressure, and has the added advantage that the effect of sympathetic inhibition on pain may be unequivocally studied. Paravertebral block is also a good method by which circulatory releases in the upper limb may be observed. But its relative difficulty is against its becoming a widely popular procedure. None the less there are certain problems which can be attacked only by its use.

Spinal anæsthesia (White, 1930, Morton and Scott, 1930).—With spinal anæsthesia reaching the level of the xiphoid process (and, indeed, with general anæsthesia) the vaso-motor supply to the lower limbs is temporarily cut off so that the vaso-motor index can be studied. Valuable use therefore can be made of spinal anæsthesia in investigating circulatory troubles in the feet. It has this advantage over all other test methods that, if satisfactory thermal changes are observed, an operation for sympathectomy can be proceeded with at once. If readings are obtained which are at variance with the estimated probabilities (such as a fall of temperature when a rise was expected), the surgeon will use an alternative method as a control.

The feet should be exposed at room temperature—a hot operating theatre is unsuitable—for twenty minutes before the first readings, at selected and marked points below the ankle. The spinal anæsthetic is then given, and readings repeated at five-minute intervals. The temperature of the sole is ordinarily greater than that of the under surface of the great toe by 3° to 8° C. Morton and Scott found the average of 22 normal cases to be 24.7°±3° C. for the toes and 30.25°±3° C. for the soles. After spinal anæsthesia the temperature rises to much the same level at all points—34.2°±2° C. and 34.5°±1.5° C. respectively. These readings represent the maximum vaso-dilator level for normal feet. In Raynaud's disease some such figure will be observed, though the initial temperatures may be lower, making the effects of vaso-motor release even more striking (Fig. 861.) In patients with vascular obstruction, equally low readings will be obtained, and such rise as does occur will depend on the amount of vaso-spasm present. If there is little or no rise, or even a fall, the condition is one of pure vascular occlusion, but if there is a rise of 5° or 6° C. the occlusion is evidently accompanied by considerable spasm. The probable benefit to be obtained by operation depends not only on how great the elevation of temperature is, but on how nearly it approaches the normal limits. For example, a rise from 21° to 26° C. is less promising than a rise from 28° to 33° C., whilst a rise of 2° C. only, unless it was at the top end of the scale, would be but a poor inducement to operation.

Paravertebral novocain block (J. C. White, 1930). This method relies on the physiological paralysis of the sympathetic fibres outside the spinal canal before they have entered the peripheral nerves. Langley (1892) showed that the sympathetic fibres destined for the upper limb leave the 2nd to the 10th thoracic segments of the spinal cord, and ascend the thoracic sympathetic trunk, whence they are distributed to the brachial plexus. These sympathetic fibres could be attacked either by direct blocking of the brachial plexus or, better, by paravertebral block (J. C. White).

Labat's technique.—For the upper limb, wheals are raised 4 cm. lateral to the tips of the spinous processes of the seventh cervical and first and second thoracic vertebræ. A fine needle, 10 cm. long, is inserted successively through each wheal perpendicularly to the skin to make contact with the neck of the rib, which is usually the one below. The needle is passed under the rib and inclined inwards at an angle of 25° towards the midline. It should reach the side of the vertebra after a course of 2 and not more than 3 cm. deep to the rib ; 5 c.c. of 1 per cent. novocain is injected slowly at each point. Reflex coughing indicates puncture of the pleura, but no harm should come of this if the needle is withdrawn and replaced. With a successful injection vaso-spasm disappears, there is relief from pain, and suppression of sweating. Indeed, the patient may at once comment on the relief of discomfort without any analgesia being observable in the limb. For the lower limb lumbar paravertebral block is used.

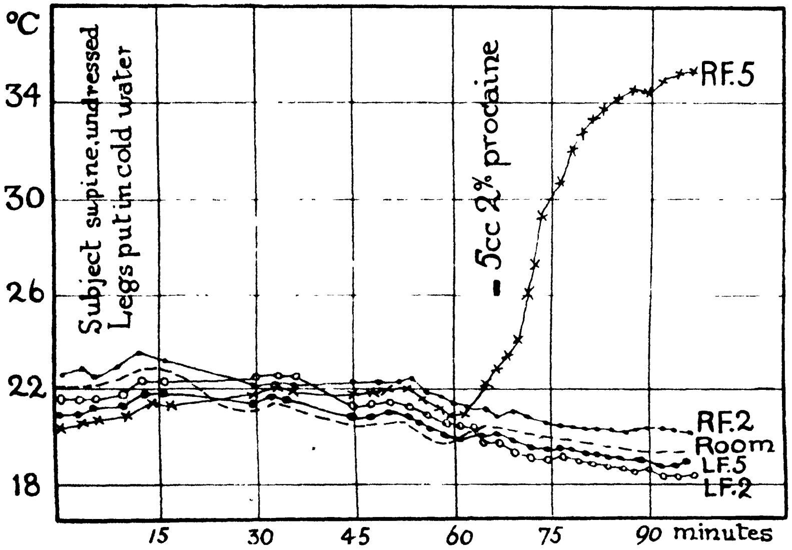

Fig. 861.—Median nerve injury. Procaine block of right stellate ganglion produced Horner's syndrome and vaso-dilatation, with temperature rise in little finger. Left hand temperature (L.F.5 and 2) followed chilling of feet and fall in room temperature. Numbers and letters refer to digits.

(Test by Dr. J. Doupe.)

The sympathetic fibres for the vessels of the leg leave the spinal cord from the lower thoracic segments (perhaps as high as the eighth) and from lumbar segments one and two, descending in the lumbar chain to the lumbar and sacral ganglia, and thence to the peripheral nerve plexuses. The patient lies with the side to be injected uppermost and the back flexed. To induce paravertebral block a long needle (12 cm.) is inserted 8 cm. from the midline, and passed forwards and inwards at an angle of 20° to the side of each lumbar vertebra (Labat). The needle is then withdrawn somewhat and the angle altered so that the point just misses the vertebral body but reaches its edge anteriorly. Ten c.c. of 1 per cent. novocain is injected after trial aspiration has proved that the needle is not in a vein. The injection is best made at the sides of three vertebræ in series. Vaso-motor paralysis of the lower limb follows a well-placed injection. Temperature measurements are made with a thermocouple and claudication tested by flexion and extension of the limb against resistance (Telford and Simmons' claudicometer).

Chemical tests.—The only chemical test, apart from alcohol—a well-known powerful vaso-dilator which, in three-ounce doses of whisky, may give as useful a result as the fever test of Brown—is the method of de Takats. He uses 1 c.c. of a 4 per cent. freshly prepared solution of sodium nitrite, administered intravenously. Vaso-dilatation occurs within ten minutes in vessels able to relax.

Heat tests.—Equally valuable observations can be made by raising the body-temperature. The fever test of Brown (1926), the earliest used, has now been largely abandoned in favour of the less disagreeable and dangerous application of external heat by means of hot-air chambers. Pickering and Lewis (1931), Gask and Ross (1934), and J. C. White (1934) have devised cabinets for this purpose. A useful one can be made by placing the patient under one of the electrically-lit cradles used in many hospitals for warming shocked subjects or for the application of radiant heat. The extremities to be tested are kept outside and exposed to cool room air. Pickering and Lewis find a cabinet temperature of 125° F. to be the best. As soon as the patient begins to perspire normal vessels in the exposed extremities relax and give temperature readings about the normal vaso-dilatation level (about 94° F.). If there is arterial occlusion by organic changes the rises of temperature in the hands or feet will be slight and far below normal. Approximation to the vaso-dilatation level is the surest index for operative purposes.

Still simpler is the method in which the forearms and hands are immersed in hot water (about 110° F.) ; this produces a rise of temperature in the feet after 15–30 minutes. (Gibbon and Landis, 1932.) The reverse arrangement may equally be used.

Others (Collar and Maddock) have found that winding a patient up to the neck in three blankets, surrounded in a mackintosh sheet, for an hour brings about a general vaso-dilatation.

P. W. Ingram (1936), in Learmonth's service, found that continuous readings from a thermocouple attached to a patient warmly covered in bed for many hours is sufficient to demonstrate the lability of vascular control. During sleep there is a full vaso-dilatation. The hand or foot to be tested is left uncovered with the thermocouple attached.

Alternatively, excellent recordings can be obtained by plethysmography or by the estimation of the opacity of the digits to a beam of light as measured with a photo-electric cell.

Interpretation of the tests.—Sufficient has already been said to make the use and interpretation of the tests fairly clear. The skin temperatures of the limbs normally vary at different levels, diminishing from the trunk towards the periphery, so that they are higher over the thigh than below the knee, and lowest over the feet and particularly over the toes. Morton and Scott have named this feature the " vascular gradient," and under spinal anæsthesia various changes may be observed in it :—

(1) The gradient may be abolished completely, so that all dermal temperatures approximate to the same level. This occurs in the normal and in pure vaso-spasm.

(2) The gradient remains unaltered or is steepened. This occurs in pure vascular occlusion.

(3) The gradient is partly obliterated owing to a rise in peripheral temperature which does not, however, reach the full normal vaso-dilation level (approximately 34° C.).

In all classes of case only those can be confidently submitted to operation which show not only a rise in skin temperature but an approximation to the normal level after diagnostic novocain block or after one of the other tests described. This will have indicated not only that sufficient collaterals exist, but that they are healthy enough to help the patient if they are permanently relaxed.

The question arises : Which of these tests is the most useful ? The answer depends on the armamentarium of the individual clinic on the one hand, and the surgeon's skill at local injections on the other. The one common denominator is the possession of a reliable thermocouple for the measurement of skin temperatures. In general, spinal anæsthesia is the easiest test for vaso-release in the lower limbs, and local infiltration with novocain of the ulnar and median nerves for similar tests in the arms. The latter method is not so applicable for the foot, because it is technically much more difficult to block all the nerves which supply the vessels to the toes. Paravertebral block, at whatever level, requires considerable practice and skill, but it is effective. The other means of raising peripheral temperatures are only possible if the requisite apparatus is available. Some one among them may make an appeal to the individual, or they can be used as confirmatory tests if a clear answer has not been obtained by one of the others.

PRE-GANGLIONIC SYMPATHECTOMY

Modern operations are pre-ganglionic ; this term means division or excision of the sympathetic fibres before they reach the ganglia from which they are distributed to the limbs. All observers agreed that it was much easier to obtain good results in the feet than in the hands. It was at first thought that sympathectomy of the upper extremity failed, or was unpredictable in its results, because it was not sufficiently complete. The great variability of the shape and courses of the branches to and from the stellate ganglion, described by Jonnesco (1923), Woollard and Norrish (1933) and Sheehan (1933) lent colour to this view. Kuntz's paper (1927), calling attention to the importance of the contribution from the second thoracic ganglion direct to the lower cord of the brachial plexus, had already emphasized the possibility of incomplete denervation in those early days when it often escaped division. However, Telford (1935) thought that the explanation might be different. He recognized that in a lumbar ganglionectomy the pre-ganglionic fibres to the foot are excised, whereas in an extirpation of the cervicothoracic (stellate) ganglion, not only was the incoming pre-ganglionic stream interrupted but the post-ganglionic fibres were necessarily cut as well. Smithwick, Freeman and White (1934), following independently the same line of thought, had already demonstrated that weak concentrations of adrenalin were capable of producing intense vaso-constriction in the human hands after post-ganglionic sympathectomy. This was a confirmation of an old observation of Lewandowski (1900), T. R. Elliott (1905), and others, that the vessels of animals become increasingly sensitive to adrenalin when the vaso-constrictor fibres have degenerated. The enhanced vaso-motor tonus of the denervated artery was proved experimentally by White, Okelberry and Whitelaw to be from two to three times greater after post-ganglionic denervation than after pre-ganglionic. This physiological work was later confirmed by Ascroft (1937), who demonstrated that it was possible to produce deliberately great adrenalin sensitization in the monkey's foot if he took away the sacral rather than the lumbar ganglia. Telford's deduction, thus confirmed by experiment, made it clear that the ganglia which were customarily removed in a cervical sympathectomy were, in truth, the most important ones to preserve. These facts caused a considerable modification in operative technique. (A description of the vaso-constrictor outflows to the upper and lower extremities will be found below and on p. 1806.) It would be sufficient if the ganglionated trunk carrying these impulses was simply divided were it not for the fear of regeneration.

SYMPATHETIC DENERVATION

Upper Extremity

Anatomy.—Although metameric arrangement can generally be observed in ganglia of the paravertebral sympathetic chains, variability in the number of ganglia is the rule. This is true not only of the neck but also of the thoracic region, where a full 12 ganglia are never seen, and of the lumbar region, in which 4 ganglia rather than 5 is common. In the cervical portion of its course the superior and largest ganglion represents the fusion of the first three ganglia. The middle ganglion tends to blend with either the superior or the inferior ganglion and is therefore often absent.

The inferior cervical, stellate, ganglion shows well the tendency to economy and variability in ganglionic masses which characterizes the sympathetic. It represents the fusion of the lower five cervical ganglia with the first and even the second thoracic (Delmas and Laux), and acquires its peculiar shape from this conglomeration as well as from the numerous branches which pass to and from it. Its position is not absolutely constant for, although in general it lies against the neck of the first rib, it may rise above it or sink largely below it, according as the conglomerate is pre- or post-fixed, to use the terms commonly applied to the brachial plexus. It is deeply placed internal to the scalenus anticus, with the vertebral artery lying in front and to its inner side. The ganglion is often in intimate relationship to this artery and may be grooved by it, but the two are easily separable.

It receives its pre-ganglionic inflow from two sources : (1) from the first thoracic nerve direct ; this branch carries the sympathetic supply to the head ; its division produces Horner's syndrome ; it contributes feebly if at all to the upper limb ; (2) from the upper spinal segments (T.2 – T.6 or more) through the paravertebral ganglionated chain which joins its lower pole ; these fibres carry the sympathetic control to the blood vessels, sweat glands and pilo-motor apparatus of the arm. It will be seen that vaso-spasm can be abolished by cutting the spinal inflow into this main ganglion from below without producing the Horner syndrome that must follow removal of the ganglion itself or resection of the white ramus that binds it to T.1. The ganglionated chain does not always carry to the stellate ganglion the whole sympathetic supply to the upper limb ; some important fibres sometimes leave the chain to join the brachial plexus direct. That from the second ganglion is sometimes called Kuntz's nerve (1927). Since these fibres are post-ganglionic they should be preserved (Telford, 1938). On the other hand, if the thoracic chain is cut across as low as T.3, the pre-ganglionic (white) rami joining T.2 and T.3 to the corresponding ganglia carry vaso-motor fibres and must be cut separately if the arterioles of the upper limb are to be fully denervated (see Fig. 862).

There are two alternatives in resecting the vaso-motor fibres to the upper extremity. The anterior approach has been the more popular in this country and has been used especially by Telford and by Gask and Ross. The posterior is the method of choice in America ; the evidence points to its being the better method. The choice depends on more than a preference for one route because of ease of access or familiarity with the approach. The sympathetic chain can be cut as low and as well in most subjects from the front as from behind. The real difference lies in the thoroughness with which the white contributions from T.2 and T.3 are removed. From the front they can only be sectioned so that regeneration is almost certain ; from the back they can be dealt with in such a manner that this is impossible, as will appear in the description that follows.

Anterior approach.—The anterior approach to the upper thoracic ganglionated chain involves a deep dissection of the structures lying in the thoracic operculum. Good exposure, perfect lighting, and narrow-bladed deep retractors are essential. A sand-bag is placed between the patient's shoulders, and the shoulder depressed as far as possible, as for an operation for cervical rib. The best anæsthetic is endotracheal gas, oxygen, and ether with premedication by omnopon, gr. $\frac{1}{3}$, and scopolamine, gr. $\frac{1}{300}$. A horizontal incision is carried across the supraclavicular triangle, commencing 1 cm. above the sterno-clavicular junction, and ending at the anterior border of the trapezius. The incision is deepened, and the external jugular vein divided. The next step consists in the division of two muscles, the greater part of the clavicular head of sternomastoid and the complete costal attachment of scalenus anticus. (Fig. 862.) The former is resutured at the close of the operation, the latter left divided. During the division of scalenus anticus the jugular vein, which comes into view when the sterno-mastoid fibres have been divided, should be held out of harm's way, and the phrenic nerve carefully retracted inwards. The division of scalenus is a simple matter if the surgeon makes a point of attacking its actual attachment, for the fibres retract as they are cut, and seem to melt beneath the knife-edge. The deepest fibres cover the subclavian artery, so that especial care is necessary in dividing them. The vessel is now displayed and must be dissected free so that it can be retracted downwards ; this freeing necessitates the division of the thyroid axis artery, after which step the vertebral artery will be more clearly seen. The superior intercostal artery will also have to be secured ; when this has been done the exposure of the ganglion is practically bloodless (Telford). The subclavian vessels are held downwards and inwards by a narrow ribbon retractor and a finger is passed inwards to identify the neck of the first rib. The sides of the

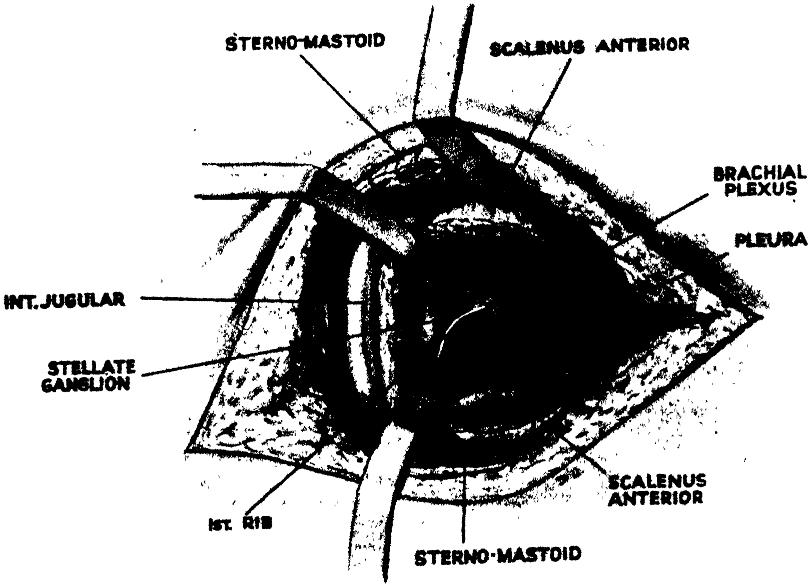

Fig 862.—Anterior approach to stellate ganglion.

bodies of the upper thoracic vertebræ are now displayed by gentle depression of the dome of the pleura after detaching Sibson's fascia from the inner border of the first rib. This is best done with the finger. The stellate ganglion should now be well in view on the neck of the first rib, and from its lower pole the thoracic cord can be followed down until it can be cut through opposite the third thoracic vertebra below the third ganglion.

The stellate ganglion itself is not removed, nor should it be crushed by applying forceps to it. The aim is to divide the thoracic chain as low as possible and to divide the pre-ganglionic white rami which run to the chain from the 2nd and 3rd spinal nerves close to the intervertebral foramina. The rami on the inner side of the stellate ganglion itself should not be cut for the reasons previously given. It would suffice if the chain were merely sectioned, were it not for the fear of regeneration. This can be largely prevented by pulling the freed chain up and suturing it to any convenient muscle stump, such as scalenus anticus. It is wise not to remove any of the ganglia, not even the second and third thoracics, for fear of the effects which the division of their post-ganglionic rami may have in sensitizing the arterioles to adrenalin. Nor should Kuntz's nerve be cut, as its fibres are post-ganglionic. In earlier days a point was made of seeking this nerve and dividing it, but this is no longer advised. The most important things to achieve are the low division of the thoracic sympathetic chain and the separation of the stumps as widely as possible to prevent reunion. A silver clip may be placed on the lower stump and squeezed tightly, but if the upper part of the cord has been properly dealt with there is no real necessity to do this.

This operation is, at first, by no means easy, the depth of the dissection being very considerable. It was originally said that it is impossible to reach the third thoracic ganglion from the front. This is certainly untrue, for a surprisingly good view of the upper 3–4 cm. of the thoracic chain can be obtained from the front by gentle traction just below the stellate ganglion and light-handed dissection.

Difficulties.—Failure to find the ganglion is due generally to poor lighting of the wound and insufficient exposure. After scalenus anticus has been divided, the neck of the first rib may be used as a landmark, for the ganglion lies in front of it. The vertebral artery has been injured, on occasion, without detriment to the patient. The thoracic duct is a possible hazard, but it is not usually seen, for the surgeon passes high over the angle between the jugular and subclavian veins, his objective being behind the subclavian atery. The pleura may be damaged, but with endotracheal anæsthesia this is a matter of little importance. If there is a ball-valve opening there may be serious trouble from imprisoned air. If there is the slightest sign of dyspnœa and cyanosis, the air should be aspirated at the close of the operation. This is done by placing a catheter in the pleural opening and sucking the air out with a large syringe—e.g., a Marrel bladder syringe—as the wound is finally closed and the catheter withdrawn.

Upper thoracic sympathectomy : posterior approach.—The approach to the stellate ganglion from behind is the one most commonly used in America. It was developed originally by A. W. Adson, based on the studies of A. K. Henry. The object of the operation was to remove the cervico-thoracic ganglion and some of the thoracic chain below it by resection of the inner ends of the first or second ribs or both. Nowadays the aim is different : it is to divide the ganglionated chain below the third ganglion, to deal with the ends in a way that will prevent regeneration, and to leave the stellate ganglion *in situ.* The modern operation is that of White and Smithwick (1936–1941).

Technique.—The inner end of the third rib is to be resected, together with the corresponding transverse process. The patient is anæsthetized by endotracheal gas and oxygen, a method which allows the use of positive pressure if the pleura is inadvertently opened. The patient is laid on his face ; the arms, well padded on their inner sides, are drawn up and fixed with slings around the wrists to cause the scapulæ to move away from the midline. Learmonth advises the identification of the third rib radiographically, especially in obese persons, the type for whom this approach is always best. A vertical incision is made, 5 cm. from the midline and about 7 cm. long, centred on the tip of the second thoracic spinous process. The incision is deepened by dividing the trapezius and rhomboids until the third rib is reached. The inner 2 inches of this rib are then excised, after it has been defined by dissection ; the third transverse process is nibbled away ; and the head of the rib, or so much of it as impedes the view, is also taken out The second and third intercostal nerves are then sought and the inner 1½ inches resected, the pleura having first been separated from the sides of the vertebræ (Fig. 863.) The thoracic sympathetic trunk is found deep to the nerves crossing their track vertically close to the vertebral bodies ; it is cut through below the third ganglion and the upper end of the divided trunk brought out of the wound, crushed, ligatured and enclosed in silk mesh ; it is then sutured to the muscles of the back. No ganglia are removed. (Fig. 863, B, C.) White and Smithwick have made a great point of following the second and third nerves as far into the intervertebral foramina as possible before cutting them medially. By traction it is possible to make the section proximal to the dorsal root-ganglia, that is to say, the anterior and posterior spinal roots of T.2. and T.3. segments are divided. In their most recent work (1941) the authors recommend that the dural envelope of these two nerves should be opened medial to the posterior root ganglion and the roots cut under vision. This necessitates strong traction which, so far, has caused no harm. White and Smithwick believe that the excellence of their results in recent years is due to the thoroughness of this operation, which leaves little opportunity for regeneration. The cerebro-spinal fluid leak into the posterior mediastinum, which necessarily follows the opening of the dura proximal to the root-ganglion, has proved to be unimportant. The silk-mesh can be made by winding silk on to a glass rod and then darning it so that it holds together as a cylinder when the rod is withdrawn. Any impermeable material would serve equally well to envelop the stub of the cut nerve provided that it quite ensheathes it.

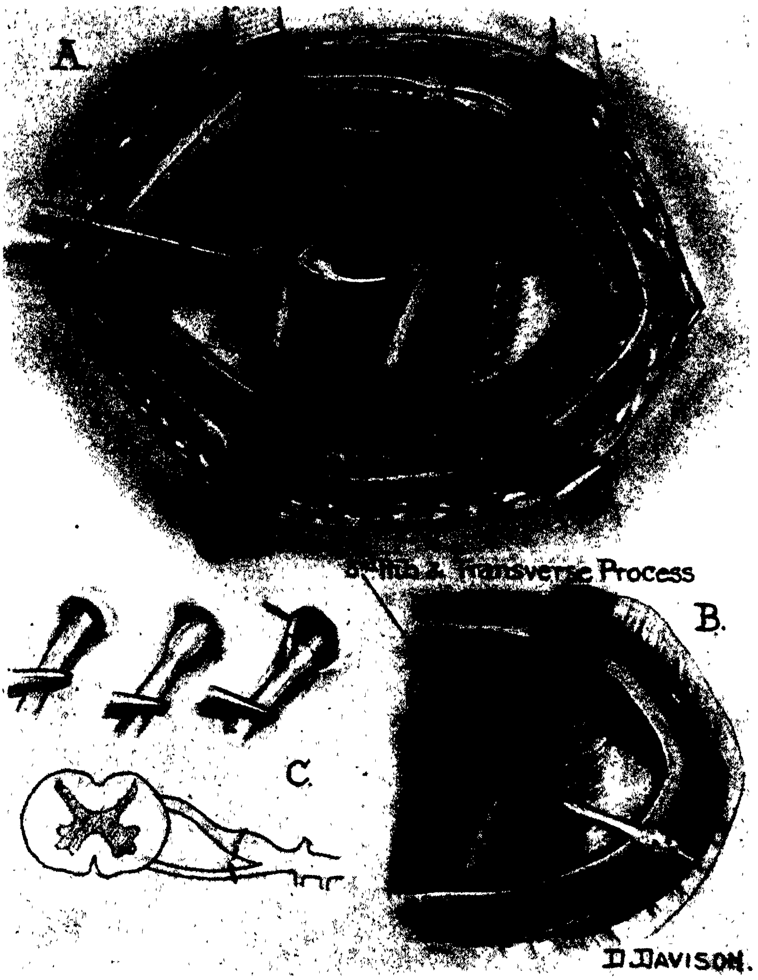

Fig. 863.—A, Diagram illustrating resection of the innermost portions of the second and third intercostal nerves and the pre-ganglionic fibres springing from them. Division of thoracic ganglionated chain without extirpation. Posterior approach, costo-transversectomy ; B, Sympathetic chain divided and sutured to muscles ; C, Resection of 2nd and 3rd intercostals proximal to or through the spinal ganglia.

Relapse after sympathectomy for vaso-spasm.—Relapse is important in the upper extremities only. The results in the lower limbs are uniformly good, provided that the vessels are permeable. There are three reasons for this : first and most important, because even the widest lumbar ganglionectomy remains essentially a pre-ganglionic sympathectomy in relation to the outflow to the vessels below the knee which comes from the sacral ganglia ; secondly, because so long a portion of the ganglionic chain is excised that regeneration is almost impossible ; thirdly, because the feet are always much better protected by clothing against external temperature variations than are the hands. Failure, relative or complete, in the upper limbs must be ascribed to one or more of the following causes : (*a*) the excision of post-ganglionic rather than pre-ganglionic fibres, producing hypersensitivity to adrenalin ; (*b*) failure to resect the desired fibres completely enough ; (*c*) regeneration of the divided nerves ; (*d*) progressive vascular obliteration, the patient having severely diseased vessel walls and a mechanical rather than a spastic obstruction to the blood-stream.

Simmons and Sheehan (1939) have classified the cases operated on in Telford's Clinic into two groups : first, those in which there has been an immediate relapse, really cases of operative failure, chiefly amongst the early cases in the series, and secondly, those in which the symptoms have recurred after an interval of several months of complete freedom—" late " relapses. In the second group Simmons and Sheehan believe that the relapses cannot be explained on any basis of hypersensibility of the blood-vessels to circulating adrenalin, and show that relapses, in the cases which they studied, have been always accompanied, and presumably caused, by regeneration of vaso-constrictor fibres. This finding emphasizes the precautions that ought to be taken to make reunion as difficult as possible. The posterior operation of White and Smithwick seems to offer the best safeguards. Other British surgeons are doubtful of the importance of the sensitivity to circulating adrenalin that White, Okelberry and Whitelaw (1936) discovered after ganglia and post-ganglionic fibres had been removed. But Ascroft (1937) produced confirmatory evidence by showing that vaso-dilatation in the monkey's leg after removing the lumbar ganglia disappeared if the sacral ganglia were excised. It is from the sacral ganglia that the vaso-motor fibres to the foot arise. The contention that sensitization is important seems, therefore, to be good.

LOWER EXTREMITY (LUMBAR GANGLIONECTOMY)

Anatomy (Fig. 864).—The lumbar sympathetic chains commence above at the diaphragm and run down to the brim of the pelvis closely applied to the antero-lateral aspects of the lumbar spine. They lie on the vertebræ immediately anterior to the origin of the psoas and its tendinous arches. The ganglia vary in number and size, four being the most usual number, but five, six or more may at times be encountered. A reduction of the number of ganglia is often met with, the fifth lumbar being absent ; sometimes the chain exists as a ganglionated cord in which the individual cell collections are difficult to recognize. The first lumbar ganglion is not easily accessible, for it lies immediately below the renal artery and covered by the pancreas. A very high dissection is necessary to expose it ; on the right side, in particular, the duodenum will have to be swept up to expose even the second ganglion, which can appear to be higher than it really is and so come to be mistaken for the first. The chains are held down by a fine, strong sheet of fascia which must be incised before they can be

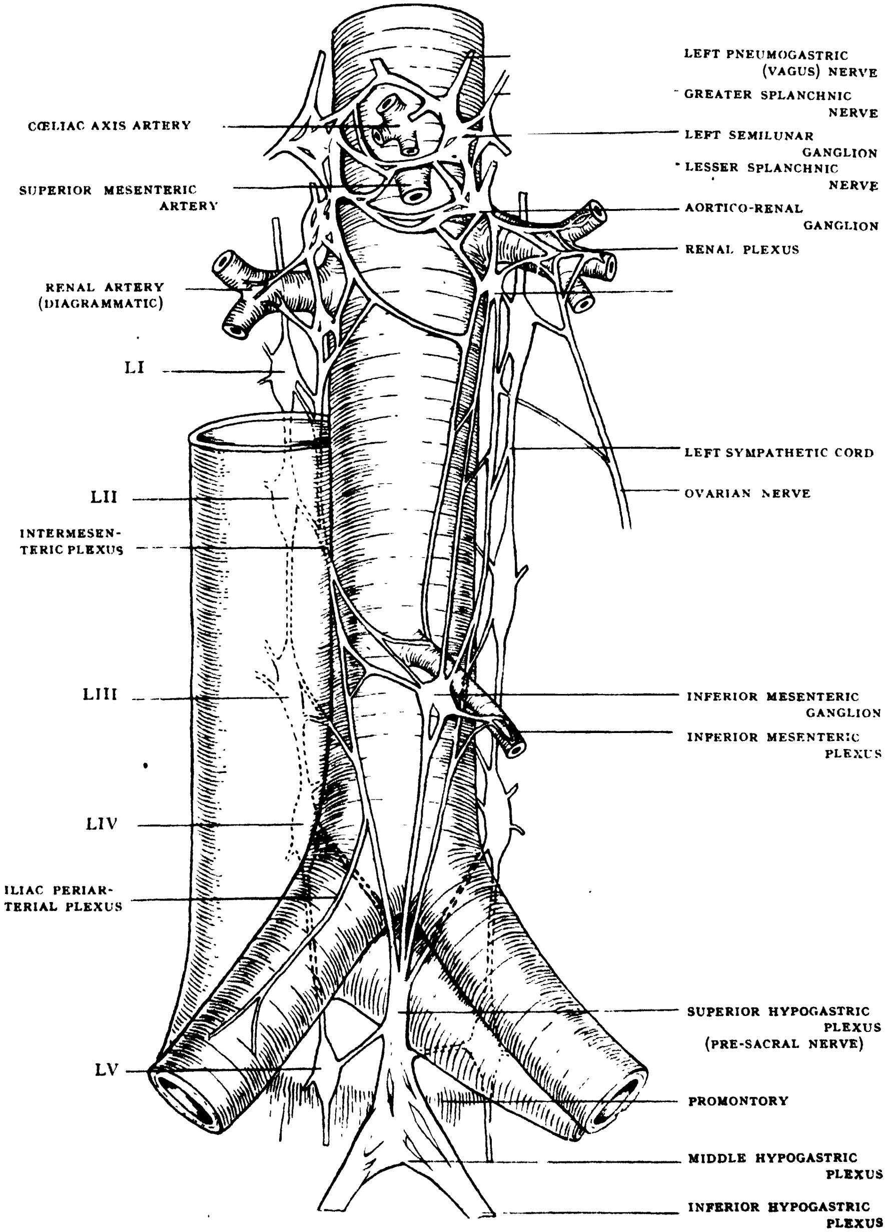
LEFT PNEUMOGASTRIC (VAGUS) NERVE
GREATER SPLANCHNIC NERVE
CŒLIAC AXIS ARTERY
LEFT SEMILUNAR GANGLION
LESSER SPLANCHNIC NERVE
SUPERIOR MESENTERIC ARTERY
AORTICO-RENAL GANGLION
RENAL PLEXUS
RENAL ARTERY (DIAGRAMMATIC)
LI
LEFT SYMPATHETIC CORD
OVARIAN NERVE
LII
INTERMESENTERIC PLEXUS
LIII
INFERIOR MESENTERIC GANGLION
INFERIOR MESENTERIC PLEXUS
LIV
ILIAC PERIARTERIAL PLEXUS
SUPERIOR HYPOGASTRIC PLEXUS (PRE-SACRAL NERVE)
LV
PROMONTORY
MIDDLE HYPOGASTRIC PLEXUS
INFERIOR HYPOGASTRIC PLEXUS

Fig. 864.—Anatomy of the lumbar sympathetic system.

(*A. A. Davis.*)

mobilized. On the right side the margin of the inferior vena cava definitely overlies the chain ; on the left side the aorta just reaches it. The first and second lumbar ganglia are joined on their outer sides by white rami communicantes passing to them from the spinal nerves. These contain the motor inhibitory fibres to the colon and are thus of some importance to the surgeon.

From the medial aspects of these two ganglia, branches run to join respectively the right and left intermesenteric nerves ; these are the lumbar splanchnic nerves. Similar branches pass inwards from the third and fourth lumbar ganglia, but there is little doubt that the branches from the first and second ganglia give the chief supply to the colon. Grey rami communicantes pass laterally from all the ganglia to join the spinal nerves after a course made long by the thickness of the psoas ; these were the fibres avulsed in the original operation of ramisectomy (Hunter and Royle). The fibres that control the blood-vessels of the lower limb and its skin appendages (sweat-glands, pilo-erection and so forth) run down the lumbar chain to pass out from the sacral ganglia. Ganglionectomy of L. 2, 3, 4, will release vaso-spasm in the lower limb, but colonic activities will not be interfered with unless the white rami joining L. 1 and to a lesser extent L. 2, or the lumbar splanchnics proceeding medially from the same ganglia, are divided (as may well happen accidentally). Ganglionectomy is a much surer operation than ramisectomy and will be the operation of choice to ensure vaso-release, the ganglia extirpated being L. 2, 3, 4 on both sides. Ascroft (1937) showed that the vaso-constrictors of the foot are given off to the sciatic nerve-roots by the sacral paravertebral ganglia, and the good results obtained by lumbar ganglionectomy for vaso-spasm of the feet were achieved because these sacral ganglia were left undisturbed. The down-flow in the lumbar cord recalls the up-flow through the thoracic chain to the stellate ganglion and so to the upper limb. When the lumbar chain is extirpated, a pre-ganglionic resection of the fibres destined for the feet is achieved. The fact that post-ganglionic fibres to the thigh, passing to and along the obturator and anterior crural nerves, are removed at the same time, is a matter of no practical importance. The precise position of the ganglia on the vertebral bodies cannot be described in a manner which is uniformly applicable, for their variation in number necessitates differing positions on the vertebral bodies or on the discs between them in different individuals. The fourth ganglion may be partly hidden beneath the iliac vessels and may require some dissection for its proper exposure.

Removal of the abdominal sympathetics was first performed extra-peritoneally through a long lumbar incision somewhat similar to that in use for exposure of the kidney and ureter. Later the transperitoneal approach from the front through a long, left rectus incision beside the umbilicus was generally preferred ; the colon was mobilized and the dissection carried medially to the sides of the vertebral bodies. Both right and left chains could be excised at the same sitting. This operation was fully described in the last edition of this book, but since then the extra-peritoneal operation has again become so much the more popular in all countries that the transperitoneal is scarcely used to-day. It will no longer be described, since the other approach is sounder and safer.

Extra-peritoneal removal of the ganglionic chain.—An adequate exposure of the chain can be achieved by lumbar incision ; its disadvantage is that in most cases both sides cannot be attacked at one time. When the operation has been done unusually quickly and easily, the surgeon has gone on to do the other side at the same sitting without undue discomfort to the patient afterwards. But if he has been held up by retroperitoneal glands and adhesions he will be happy to make it a unilateral operation. The operation has many points in its favour since the viscera are very little disturbed, and all possibilities of peritoneal reactions are avoided.

Technique.—Spinal anæsthesia is used. The incisions commonly employed to-day differ from the original and are two ; they are illustrated in Fig. 865. One is a very long muscle-splitting incision (Flotow 1933, Pearl 1937) running from the lower costal margin at the anterior axillary line, obliquely downwards and inwards to meet the outer border of the rectus sheath four inches above the pubis. (Fig. 865, C). It is lateral rather than lumbar. With the patient recumbent, the external oblique is split in the direction of its fibres along the whole length of the wound and especially far out laterally. The fibres are well retracted, and those of the internal oblique are similarly divided upwards and inwards from just above the crest of the ilium to the rectus muscle. The transversalis muscle and fascia are next divided horizontally, and through this opening the peritoneal sac, covered by the extra-peritoneal fat, is dissected up and pushed medially by blunt dissection with the fingers and moist gauze. The hand passes over the front of the quadratus lumborum and psoas until the bodies of the vertebræ can be felt. The ureter and spermatic or ovarian vessels are dissected up with the peritoneum. Large and deep retractors are now needed to provide proper visibility in the depths. The Royle type are useful, but narrow long-bladed gall-bladder retractors are satisfactory. By dissection downwards to the iliac vessels and upwards to the renal, the whole length of the lumbar sympathetic chain can eventually be seen as high as the first ganglion. The aorta on the left side, and more especially the inferior vena cava on the right, overhang the chain and must be carefully held out of the way. The chain is best discovered by palpation ; a thin, hard cord will be felt lying on the vertebral bodies and discs immediately beyond the point where the psoas joins the spinal column. It is a distinct cord with ganglionic enlargements about 3 cm. apart, firmly laced on to the posterior abdominal wall by fine branches of considerable tensile strength running backwards into the psoas or between it and the vertebral bodies in company with the lumbar vessels. The strength of the chain when it is picked up with a fine hook distinguishes it. The trunk may be crossed anteriorly by lumbar veins. The relationship of these veins is variable and only rarely do they require ligature, with fine silk or thread that bites the wall and will not slip. Usually it is possible to divide the sympathetic trunk and withdraw it from beneath the veins. Good lighting is important; a Cameron light is helpful. A length of the chain containing at least three ganglia (usually L.2, 3, 4) is fully liberated and removed. The peritoneal sac falls back into place when the retractors are removed and the wound is sutured in layers without drainage.

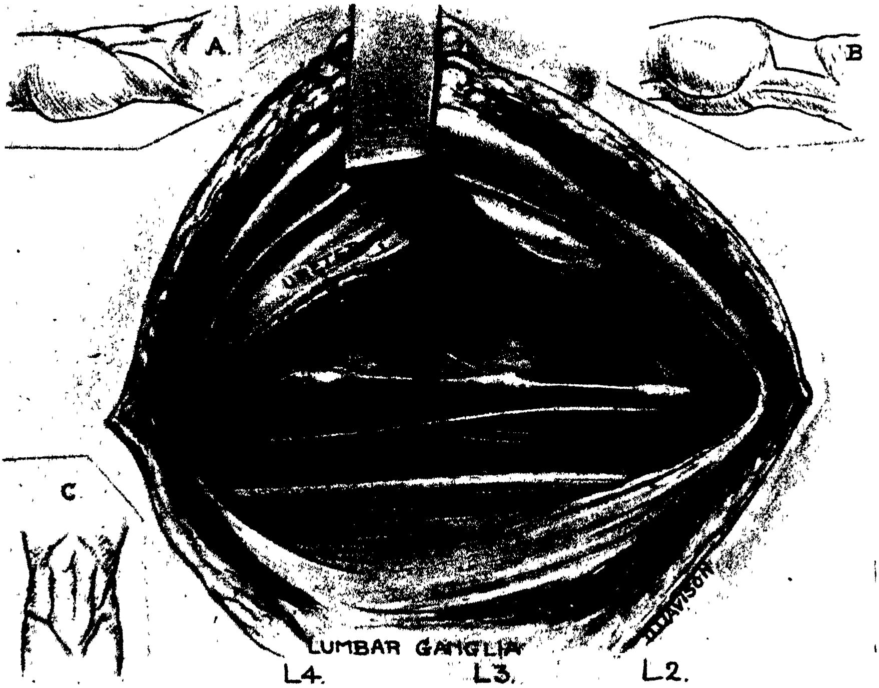

Fig. 865.—Lumbar ganglionectomy.

A, Modern lumbar incision. B, Royle type. C, Pearl-Flothow incision.

The other incision, which some prefer, is no more than a long kidney incision. (Fig. 865, A.) With the patient under spinal anæsthesia as before and lying on the opposite side, the flank to be operated upon is widened by the use of the kidney bridge. The patient's knees are drawn up and the trunk tilted somewhat backwards to allow better access to the front. Sandbags are needed to maintain the posture. A long incision is made from the outer edge of sacro-spinalis, a finger's breadth below the last rib, the direction of which it follows to its tip before curving forwards and downwards to meet the iliac crest close behind the anterior superior spine. The wound is deepened by cutting the lateral fibres of latissimus dorsi ; the posterior edge of the external oblique is dissected out and held forwards. The internal oblique and the lumbar fascia are now in view ; they are divided in the direction of the wound for a length of 3 or 4 in. The retroperitoneal space is entered below the pole of the kidney and the dissection carried to the chain on the sides of the vertebræ as in the operation just described. Both sides can sometimes be operated upon at the same session. The points that will influence the surgeon on this head will be the condition of the patient, the length of time already expended on the first side, and the estimated time before the spinal anæsthesia wears off.

Difficulties.—The chief difficulties that may be met with in the course of the operation are these :

(*a*) Insufficient exposure through the use of too short an incision and insufficient relaxation.

(*b*) Obstruction of approach by glands in the root of the mesentery ; this can cause the greatest possible difficulty when the glands are large and very adherent, and they may have to be dissected away before the sides of the vertebræ can be reached. Inflammatory changes are also common and may call for considerable dissection before the ganglion chain is clearly defined.

(*c*) High bifurcation of the aorta so that only the second and third ganglia can be readily exposed.

(*d*) Deformity of the spine, especially severe scoliosis, which is capable of producing very considerable distortion in paravertebral relationships.

The average uncomplicated case should present no serious difficulty, and the operation, apart from the exceptional cases instanced, is simple. However, difficulties (*b*) and (*c*) may be met with more often than the surgeon would wish. The advantages of spinal anæsthesia have been already mentioned and, indeed, inhalation anæsthesia always adds to the difficulty of the operation. Damage to the lumbar veins may occasionally occur even in the most gentle hands, but repair does not severely tax surgical ingenuity. Any spinal-nerve branches that come into view must be dealt with carefully, for heavy gauze pressure or stripping can sometimes set up a postoperative neuritis that will take long to subside.

Results of ganglionectomy.—(*a*) **Raynaud's disease.** Upper limb.—Mayo and Adson (1932) 39 cases ; average change of colour and pain relief, 85 per cent. Telford and Stopford (1934) 22 operations ; 11 complete successes, 8 incomplete but good, 3 failures. Massachusetts General Hospital (1941) : 53 cures, 3 failure. Gask and Ross (1934) Anterior approach ; 18 operations in 10 cases ; 8 successes, 2 improved.

Lower limb.—Mayo and Adson (1932) 15 cases ; 100 per cent. cured. Telford and Stopford (1934) 8 cases, all cured. White and Smithwick : 18 cases, all cured.

(*b*) **Thrombo-angiitis obliterans.**—Mayo and Adson (1932) : upper limb, 15 cases ; lower limb, 89 cases ; 85 per cent. relief ; 4 cases had four-limb sympathectomies. Mortality 6 per cent. from coronary disease, embolism, etc. Telford (1937) : 22 cases from 3 to 6 years post-operation, 16 well, no progress of disease ; 6 some evidence of deterioration ; 4 required amputation. Diez (1930) : 75 cases, 77 per cent. successes. White and Smithwick (1941) : 30 cases, 22 good results.

(c) **For circulatory changes in poliomyelitis.**—Robertson (1934), from Toronto Children's Hospital : 68 cases, average result excellent.

HIRSCHSPRUNG'S DISEASE AND SEVERE CONSTIPATION

It has been within the experience of most surgeons for years past to observe the effects of removal of sympathetic inhibition on the intestine under spinal anæsthesia; indeed, therapeutic use has been made of this fact in the treatment of paralytic ileus. Spinal anæsthesia stops the visceral inhibitory outflow from the cord just as surely as it removes vaso-constrictor influences. Active peristalsis can be seen in all cases when the abdomen is first opened, and immediate bowel actions after the cutting of constricting bands causing intestinal obstruction have come to be almost commonplaces under spinal anæsthesia. Further, stimulation of the lumbar chain causes inhibition of intestinal movement, while its removal releases colonic peristalsis or increases its amplitude (Learmonth, Trumble). It is logical permanently to suppress sympathetic inhibition in those patients in whom it has achieved an unnatural dominance, especially in megacolon.

Royle noted an improvement in bowel function of patients after the first removals of lumbar sympathetic chain and ganglion which were carried out for a now discarded purpose—to reduce tone in spastic paralysis of the lower limbs; Wade (1927) first deliberately applied to megacolon the lessons thus learned. There were many suggestions that sympathectomy would find a great field of usefulness not only in megacolon but in chronic constipation. Little progress has been made in the latter state, for it is known that many possible subjects are psychopaths and not likely to co-operate well in the necessary after-care. Those who are not psychoneurotics do not seem to suffer ill effects from infrequent bowel actions. Scott and Morton (1936) demonstrated the value of spinal anæsthesia as a test of inhibition of sympathetic control in Hirschsprung's disease. The bowel of the patient with megacolon will hold great quantities of fluid, and if this is a barium enema it will be seen that the colon retains great quantities, which the patient is unable to expel. Under spinal anæsthesia rather less can be introduced, and the colon is seen to be of much less diameter, while the subject is able to expel a great deal of the injected fluid, even though handicapped by an inefficiently contracting abdominal wall. After operation those improved faculties are retained and gradually enhanced, until the normal haustrations of the colon once more become visible.

Should operation be performed on the proved case of megacolon ? Telford and Simmons (1939) demonstrated that in many young children normal bowel function can be restored by a single high spinal anæsthetic. There is less inclination to operate on these cases to-day because of this discovery, coupled with the observation that many can be cured by medical care, especially by the use of acetylbeta-methylcholine bromide (Law, 1940) and liquid paraffin until the evacuation habit is restored. The importance of the mental state of these patients is unquestioned ; some of them are backward and, unless they can be re-educated, their apathy will defeat any attempt to cure them.

If operation is necessary, what should be done ? The immediate nerve supply to the expulsive portion of the colon is the inferior mesenteric ganglion and the fibres passing thence to the colon. This ganglion is not easily recognized at operation, and indeed it is a name applied to a regional cell-station rather than to a single large node. To remove this ganglion it is necessary to strip the aorta at the origin of the inferior mesenteric artery and to carry this denudation out along the vessel, not overlooking its deep surface where many fibres lie. This operation gave good results in the hands of some surgeons, its only drawback being the uncertainty of discovery of sufficient fibres to get the full effect. Rankin and Learmonth added to this inferior mesenteric ganglionectomy (if it may be so called) resection of the presacral nerve which removes the "brake" action from the smooth sphincter of the rectum as well. This operation had much to recommend it, particularly in those not uncommon cases of Hirschsprung's disease where bladder stasis was added to colonic achalasia. These operations are figured schematically in Fig. 866. It is of historical interest to examine these alternatives, which are physiologically correct but technically very difficult. Not only was it often impossible to find and divide all the required nerves but it was not practicable to prevent their regeneration.

The standard operation to-day is a high lumbar ganglionectomy with removal of the first and second ganglionic enlargements, preferably through a lumbar incision. The operation differs from that for vasospasm of the lower extremities only in this, that it is concerned with the highest lumbar ganglia alone. It is a moot point whether both sides need to be operated upon ; when the colonic dilatation preponderates in one half of the colon it may be sufficient to remove the first and second ganglia from the appropriate side. This has proved to be sufficient in practice although theoretically, since the colon is a midline structure, it should be needful to make a bilateral excision. The advantage in doing a unilateral operation, if possible, is that excision of the first and second ganglia from both sides will stop ejaculation, though not penile erection.

Results.—R. B. Wade : 18 cases ; prefers the lumbar route. Failure in 8 cases with unilateral sympathectomy until the other side was done. Results good, though not always at once.

Sargent and Boggon : 7 cases ; 4 excellent, 2 good, 1 failure. Adson : 10 cases, relief in all. Trumble : 5 cases cured by inferior mesenteric neurectomy.

Robertson, Toronto Children's Hospital cases : 9 cases, results good. Two late deaths due to neglect of bowel care, which must be sustained.

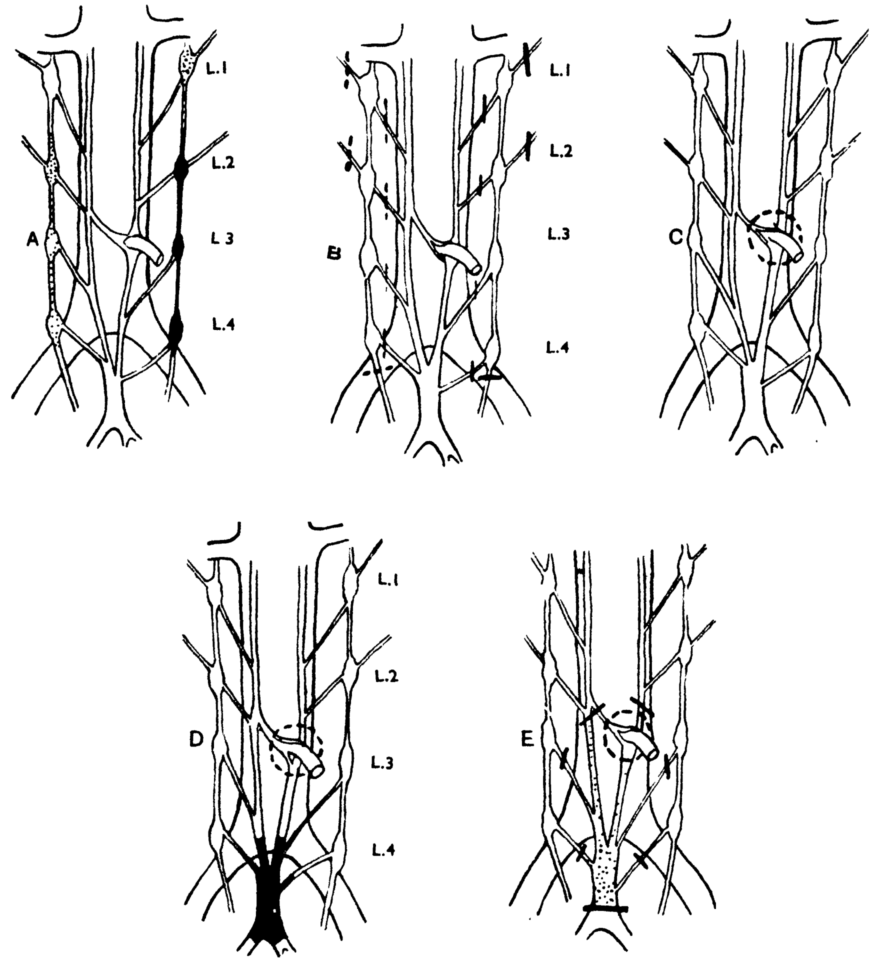

Fig. 866.—Schema of possible operations for megacolon.

A, Uni- or bi-lateral ganglionectomy (Adson) ; B, Division of white rami and lumbar splanchnics plus section of lumbar cord (Wade) ; C, Inferior mesenteric neurectomy (Trumble) ; D, Inferior mesenteric neurectomy plus resection of presacral nerve (Rankin and Learmonth) ; E, Inferior mesenteric neurectomy, division of lumbar splanchnic inflow, division of presacral nerve (Adamson and Aird).

SYMPATHECTOMY FOR AFFECTIONS OF THE PELVIC VISCERA

Indications.—In order to relieve various disorders of the pelvic viscera division of the presacral nerve has been freely performed, notably in France. The effects aimed at group themselves conveniently into sensory and motor. But although these terms are used it must be re-affirmed that there is no proof that sympathetic nerves are ever sensory. It is universally admitted that sensory fibres from the viscera run with the sympathetic nerves, but it is generally held that they belong to the cerebro-spinal system and not to the autonomic. Resection of a leash of sympathetic fibres might therefore relieve pain either because true sympathetic components (motor to the walls of blood-vessels or viscera) have been cut, or because long sensory afferents destined for the posterior spinal roots have been divided. The conditions for which presacral neurectomy has been found successful in practice are set out as follows :

Sensory :—

1. Intractable and crippling dysmenorrhœa, which the usual minor operative measures have failed to cure. Cases should be selected with care.
2. Idiopathic pelvic neuralgia in either sex.
3. Inoperable carcinoma of the cervix uteri, though here the relief of pain is short-lived (about three months in many cases, though some have obtained longer freedom). Some surgeons have recorded uniformly favourable results, but it may well be doubted whether the results are as successful as some of the reporters would have us believe. Chordotomy or subarachnoid alcohol injection is better.
4. Pruritis ani and vulvæ—but none would suggest that the presacral nerve has a sensory supply to the skin of the perineum. The result, if good, must be an efferent release effect.
5. Cystalgia due to chronic interstitial cystitis or to old healed tuberculosis of the bladder. Some cases of malignant disease of the bladder have been relieved by presacral neurectomy.

Motor :—

1. " Cord bladder " due to chronic nervous diseases or the residuum of spinal injury, cases in which incomplete bladder emptying is causing disability, pain, and danger from back-pressure (Learmonth 1931).
2. Hirschsprung's disease and constipation (possibly).
3. To prevent retention of urine after the partial damage to the nervi erigentes which is unavoidable in perineal excision of the rectum for carcinoma (Simmons 1938.)

At the present day, the indications for presacral neurectomy are very few. Of the various indications only one has been widely accepted : spasmodic dysmenorrhœa, and even here it is not every gynæcologist who prefers it to other methods, or who has abiding faith in it. In inoperable carcinoma of the cervix, its opponents can strongly urge that intractable pain arises from the extension of growth to the lateral walls of the pelvis involving the sacral plexus and its branches, such as the sciatic nerve. Such pain can only be dealt with adequately by chordotomy, less effectively by subarachnoid injection of alcohol. In " cord bladder " it is useless to divide the pre-sacral nerve if the bladder is deprived of all cerebro-spinal connections (i.e. in total lesions, whether of the spinal cord or cauda equina). The bladder is capable of partly emptying itself after all nervous connections have been cut. There is not enough evidence to allow the formulation of an operative procedure that will ensure its emptying (Denny-Brown and Robertson 1933–35). Damage to the parasympathetic nerve supply, on the contrary, is always disabling to micturition. For retention following perineal excision of the rectum the results are not uniform in all individuals. In Hirschsprung's disease a better operation is high lumbar ganglionectomy if pharmacological methods and spinal anæsthesia have failed to cure.

Anatomy.—The presacral nerve is not usually a single trunk but a small plexus, as is implied by the title given to it by the older writers—superior hypogastric plexus. Nor is it truly presacral, it is essentially prelumbar, lying on the anterior aspect of the fifth lumbar vertebra and the sacral promontory, having arisen approximately at the point where the aorta divides to form the common iliac arteries. The " nerve " takes the form of an elongated triangle with its apex upwards, a shape due to its origin by the confluence of two nerves above, and its breaking up into two downward and laterally directed branches below. The confluent nerves, arising above from the intermesenteric plexus, which courses in the shape of two sets of fibres down the right and left sides of the aorta (Fig. 864), may not break away at once, but may run together for a centimetre or two. In that case there is a definite presacral nerve-bundle, but it is always short, and in the majority of the cases no sooner do the nerves approximate than they veer away again. A. A. Davis found a plexus of 3 to 5 parallel fine fibres in fifty per cent. of his dissections. The nerve, or plexus, is surrounded by rather dense connective tissue, which binds the fibres into the shape of a wide flat ribbon cut to form a long-sided triangle. Section demonstrates that this structure consists of a few bundles of nerve-fibres, embedded in loose connective tissue. The nerve descends in front of, and parallel with, the middle sacral artery (for which, indeed, it has been mistaken), either down the middle of Elaut's interiliac trigone (the space bounded above and at the sides by the diverging iliac vessels, and below by the promontory of the sacrum), or, even more commonly, definitely in the left half of this trigone, where, too, the left ureter may be found. The nerve is not adherent to the peritoneum, which may be lifted off even in spare subjects. None the less, if the nerve is not readily found it has probably been dissected up in the retroperitoneal fat, and should be sought beneath the left peritoneal flap. The nerve is tough and not readily broken, a useful point in verification. In almost one case in ten the right leaf of the pelvic mesocolon covers the site of the nerve, rendering exposure a matter of greater difficulty.

Parasympathetic supply to the pelvic viscera.—These nerves arise chiefly from the roots of S.2 and S.3, more rarely from S.4, the contribution from which is always very small. The fibres emerge from the anterior sacral foramina, thence they pass through the inferior hypogastric ganglia to reach the bladder neck and rectum. Stimulation of these nerves leads to contraction of the walls of the bladder and rectum and relaxation of their sphincters. Simmons (1938) believes that S.2 is chiefly concerned with the bladder, S.3 and 4 with the rectum, though the fields of supply are not sharply defined.

Technique.—The operation is most easily performed through a midline subumbilical incision under spinal anæsthesia. The patient is placed in the Trendelenburg position, and the intestines packed off as for a pelvic operation. In most subjects the bifurcation of the aorta and the front of the fifth lumbar vertebra are readily exposed ; in some the root of the sigmoid partly obscures this area but can be freed sufficiently by a few touches of the knife on its right-hand side. The root of the mesentery of the small intestine lies above and gives no trouble. In a reasonably spare person the filaments of the presacral nerve plexus on the front of the fifth lumbar vertebra can be seen through the peritoneum, but no great reliance can be placed on this point. A vertical incision through the peritoneum, 5 cm. long, allows the nerve to be identified amongst the retroperitoneal tissues and followed upwards and downwards for a sufficient distance. If there is any doubt, the fibres can be even better detected as they descend across the left common iliac vein. Only rarely is the nerve a definite single cord ; more often there are many isolated fibres held together by fibrous tissue. The most certain method of effecting complete removal is to resect the fibro-cellular tissue in which the nerves run, from the aortic bifurcation to the promontory below, and as far out as the right common iliac artery on one side, the left common iliac vein on the other (Davis). A length of the nerve is removed, and the incision in the posterior layer of peritoneum closed by a continuous fine catgut suture. Bleeding is negligible. (Fig. 867.)

When the operation is being performed for the relief of pain in particular, it will be wiser to add to the presacral neurectomy excision of the rami on the other side of the paravertebral sacral chains, as well as section of that chain below the fourth lumbar ganglion.

The postoperative course is smooth with little trouble from " gas-pains," the passage of flatus being remarkably easy. Menstruation often occurs on the first postoperative day, and the possibility of menorrhagia speaks also of the increased vascularity of the uterine mucosa.

Results.—Female pelvic viscera : Cotte reports nearly 100 per cent. cures ; all types of case. He advises denudation of the aortic bifurcation and iliac vessels as well (periarterial neurectomy) and suggests performing a presacral neurectomy at the same time as hysterectomy in malignant cases where recurrence seems likely. Ferey found that in 25 per cent. of cervical cancer the pain recurred within three months ; 47 per cent. of his cases were cured. De Grisogond cured 70 per cent. of all types (21 cases).

Petit-Dutaillis thinks the operation rarely indicated and the results equivocal.

Addis and Davis :—17 cases ; 50 per cent. cured, 25 per cent. improved, 25 per cent. failures. Pruritis vulvæ : 3 cases ; 2 cured, 1 failure.

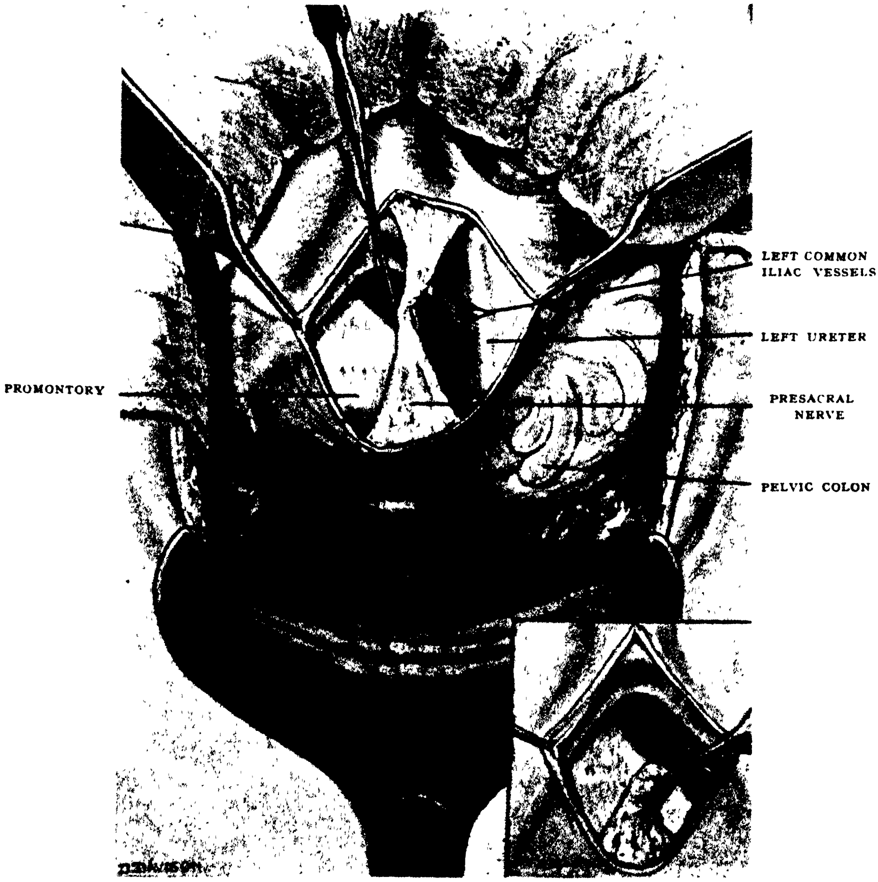

Fig. 867.—Presacral neurectomy.

Learmonth and Braasch :—

(*a*) For cord bladder—4 cases ; 2 cured, 1 improved, 1 not improved. Also one case of neuro-muscular imbalance (achalasia) cured.

(*b*) Exploration spina bifida occulta + presacral neurectomy + sphincterotomy—3 cases ; 2 improved, 1 not improved.

(*c*) Vesical pain—3 presacral neurectomies ; 1 cured, 1 slightly improved, 1 failure.

F. H. Colby (1932) : For cord-bladder, 2 cases, 1 complete success, 1 failure.

Hamilton Bailey (1933) : For cord-bladder, 1 complete success.

SYMPATHECTOMY FOR ANGINA PECTORIS

Knowledge of the innervation of the heart has grown rapidly since surgery has attacked the problem of anginal pain. The actual genesis of this pain is not yet agreed, but clearly there is no uniform pathological background. Whether the pain originates in the coronary arteries, or develops through anoxæmia of the cardiac musculature, or through hypertension in the aortic arch, the fact remains that the anginal patient is very apt to die from coronary thrombosis and infarction. The mortality of sympathectomy for angina is not formidable, but it is sufficiently high to encourage discretion. But bilateral sympathectomy has now been performed on a great many occasions in patients with normal and abnormal hearts, and no ill-effects have been observed. We may assume, therefore, that any operations that have been done have always left a sufficiency of sympathetic fibres behind though pain has been diminished or abolished.

Innervation of the heart.—Fibres to the heart run not only from the three cervical ganglia by the superior, middle, and inferior cardiac nerves, but a further series of rami course direct to the cardiac plexuses from the upper four to six intercostal nerves (Kuntz). Surgical experiences have now conclusively proved that cardiac pain can be abolished by interrupting the thoracic inflow, abandoning the older operations on the upper cervical ganglia. Two alternative methods are available : (1) excision of the stellate and middle cervical ganglion, together with the second and third thoracic ganglia (White, 1940) ; (2) division of the grey rami that connect the 2nd, 3rd, and 4th thoracic ganglia with the posterior nerve roots (Raney, 1938). Removal of the stellate ganglion alone, although advocated by Leriche, gives uncertain results and is not to be preferred. The first operation is carried out by a technique resembling sympathectomy for Raynaud's disease of the upper limb from the front, the second by a posterior approach after removing the 2nd and 3rd ribs. The mortality of either is remarkably low. Pain is abolished only on the side operated upon, but fortunately it is rarely bilateral. Instead of excision of ganglia or cutting grey rami, great relief can be afforded by paravertebral injections of alcohol. This is a treatment especially applicable to the bad surgical risk.

PARAVERTEBRAL INJECTIONS FOR THE RELIEF OF PAIN

Angina Pectoris.—The fact that anginal attacks can be stopped by paravertebral block appears to have been discovered by Mandl (1925). The freedom from pain is naturally short if novocain is used, therefore alcohol was substituted by Swetlow (1926) and has been further used by J. C. White (1928–1940).

In all cases preliminary studies with paravertebral novocain injections must be made in order to define precisely the areas to be injected. White has shown that 5 c.c. of alcohol placed in the areolar tissues on the sides of the vertebræ lead to a dense scar only 1 cm. in diameter. It is necessary, therefore, to place the alcohol accurately ;

to attain this it is best to inject not more than 2 c.c. of 2 per cent. novocain as the test injection. This quantity is placed at the innermost end of each of the upper five or six intervertebral spaces on the left side at one sitting. The results are most encouraging, though, owing to the difficulties of accurate placement, some failures are inevitable. The only troublesome effects noted have been hyperæsthesia of the skin due to intercostal nerve irritation. (One case has recently been reported of a Brown-Séquard palsy following a paravertebral alcohol injection, wrongly made horizontally so that the needle was directed at the intervertebral foramen.)

The technique employed is that already described (p. 1797) save that four spaces are injected. The highest puncture passes below the neck of the first rib, and probably the upper two are the most important. The ganglionated chains are 3 cm. deep to the transverse processes. All four of the 10 cm. Labat's needles should be inserted before any injection is made ; the depth and inclination of the needles may suggest readjustments. Five cubic centimetres of 95 per cent. alcohol is injected very slowly through each needle. This method seems logically to be the best that could be employed for anginal crises, but the neuritis it causes can be embarrassing.

SYMPATHECTOMY FOR ESSENTIAL HYPERTENSION

In the last 6 or 7 years a considerable volume of literature has accumulated on the subject of experimentally induced hypertension. The original stimulus for this research was provided by Goldblatt's demonstration (1934) that relative renal ischæmia led to hypertension in dogs ; this has been repeatedly confirmed by others. Further, I. H. Page (1940) claims to have isolated a pressor substance, "angiotonin," from such ischæmic kidneys. Whether the arteriolar spasm or obstruction which leads to elevation of blood-pressure is primarily a renal disorder, or has its origin elsewhere, is still unsettled. Ellis (1942), from an extensive study of chronic renal disease in man in its relation to hypertension, believes that the rise of blood-pressure is primary, the kidney change secondary. It has further been shown by experiment that a gross elevation of blood-pressure can be caused by denervation or excision of the carotid sinuses and section of the cardio-aortic depressor nerves (Heymans and Brouckhaert, 1931 ; Grimson, 1941). Evidently an extra-renal cause can exist. This is best exemplified by the comparatively rare finding in hyperpietic subjects of adrenal tumours, especially those of the medulla, removal of which restores the blood-pressure to normal levels (Adson, Walters, and Barker, 1939). On the other hand, unilateral renal disease in man has been shown to have been the causal agent by the reduction of pressure after removal of a chronically infected or otherwise abnormal kidney. Goldblatt (1941) issued a cautionary note, advising that nephrectomy should not be done unless the grossly pathological state of the kidney calls for its removal irrespective of the state of the blood-pressure.

It is still uncertain whether the operations which have been so widely undertaken for hyperpiesis in the relatively young produce lasting results. The attempt to create low-pressure areas in the abdomen and lower limbs in which blood may pool, at the same time denervating the adrenals and removing the vaso-constrictors of the renal vessels, has met with less success than the surgeon hoped, though perhaps with more than the physiologist would have anticipated. Nor has the relative failure been due to lack of ingenuity or courage on the part of the operator. The organs controlled or, it would be better to say, moderated by sympathetic influence have remarkable powers of getting along without nervous intervention. Cannon's completely sympathectomized dogs had low blood-pressures at first, but after a few months they recovered tone and even showed responsiveness to vaso-tonic stimuli. The hypertensive dog is not affected by sympathectomy, which in men may have little effect on pressure readings in recumbency, though considerable falls occur when the erect posture is assumed. This is especially true of the Smithwick operation. This surgeon and White (1941), and Page and Corcoran (1941) make the obvious suggestion that the difference between the effects in animals and man lie in the dissimilarity of their normal postures.

Selection of cases for operation.—It is customary to classify hyperpietic subjects into four groups based on eye-ground changes, the retinal vessels having been chosen because they are the most easily visible and because changes there are early. In Group I the arterioles are constricted, the vessels therefore are pale ; in Group II the arteries are more tortuous and nick the veins when they cross over them ; in Group III the vascular changes are more pronounced, with hæmorrhages ; in Group IV there is papillœdema with hæmorrhage and exudate. This last stage is generally called " malignant hypertension." It is agreed that aged persons are unsuitable for operation, whilst gross renal disease, advanced heart disease, and encephalopathy are absolute contra-indications. If renal function is satisfactory, if the kidneys are capable of concentrating to 1020 or better, if the blood urea concentration is normal and if there are no retinal hæmorrhages or œdema, a good result may be obtained. If, on the other hand, the blood-pressure, especially the diastolic, is very high (140-160) and does not vary with rest in bed, if it does not fall significantly after three doses of amytal (gr. 3 every hour) then an unfavourable result is probable. The Americans lay great stress on the measurement of renal blood flow and renal function by Homer Smith's methods. The flow is reduced in essential hypertension ; a great reduction is a contra-indication to surgery. Nephrectomy of a supposedly diseased kidney purely for the relief of hypertension is very apt to fail, and will do so until some better method is devised of selecting cases on accurate physiological grounds.

The results are best in the mildest cases, those which are least likely to be offered to the surgeon. An analysis of results has recently been made by J. C. White and R. H. Smithwick (1941). In their own thirty-six recent cases, operated upon by the new technique, they had good results in 6 cases of Group I, 5 Group II, 8 Group III, and 4 Group IV (63 per cent. in all). In 224 cases reported by Allen and Adson (1940) from the Mayo Clinic the good results were 45 per cent. in Group I, 35 per cent. in Group II, 26 per cent. in Group III, and 0 in Group IV. Of Peet's 290 cases the blood-pressure returned to normal in 11.7 per cent., it was markedly reduced in 7.6 and significantly reduced in 51.4 per cent. All with experience claim that headache and fatigue, the two commonest symptoms, are cured in 90 per cent. of cases even when the blood-pressure is not much altered. No explanation has been offered.

Object of sympathectomy.—The original aim of sympathectomy for hypertension was to enlarge the blood storage spaces in the abdomen and lower limbs. There is evidence that splanchnic resection, which is the standard operation, has a dilator effect on the renal vessels and, in addition, that the production of adrenalin is diminished. Local denervation of the kidney or of the adrenal glands is no longer attempted. Excision of the cœliac ganglion is not advisable because it entails section of post-ganglionic fibres. Pre-ganglionic denervation both of the kidneys and of the pressor adrenal organ is included in the global nerve resection to be described below.

Choice of operation.—Tentatives in the form of extensive anterior root section (Adson), cœliac ganglionectomy and partial section of the adrenal (Crile, Adson) are now only of historical interest. They were replaced by the sub-diaphragmatic excision of the splanchnic nerves and the upper two lumbar ganglia (Craig and Adson, 1934) and by the supra-diaphragmatic removal of all three splanchnics and of the lower three thoracic ganglia (Peet, 1935). Peet, who has operated upon more hypertensives than anyone, does both sides at the same sitting after removing 5 cm. of the eleventh rib through a vertical incision placed 5 cm. from the mid-line. The Craig-Adson operation is performed through a modified kidney incision, removing the inner half of the twelfth rib. The splanchnics are found where they pierce the crus of the diaphragm and are followed to the cœliac ganglion, the lateral part of which is removed together with the nerves ; the upper two ganglia of the lumbar chain are also excised. The operation allows the exploration (and decapsulation if need be) of the kidney, and examination for a secreting adrenal tumour which may be the rare cause of hypertension in man. One side is dealt with at a time at one or two weeks' interval. These operations are likely to be superseded by the Smithwick operation which, by incising the diaphragm, combines the advantages of both and is the most complete splanchnic denervation yet devised.

The Smithwick thoraco-lumbar splanchnic sympathectomy.—Under general anæsthesia, with the patient semi-prone, a vertical incision is commenced 5 cm. from the midline opposite the 11th rib and runs down to a point just below the 12th, when it swings outwards to follow the direction of the rib to a point some 10 cm. beyond the lateral margin of the sacro-spinalis (erector spinæ). The wound is deepened into the sheath of the latter muscle, which is retracted inwards and held out of the way throughout the operation, the lumbar muscles being divided just below the 12th rib. This rib is cleaned and removed to allow easier retractions of the wound margin during the deep dissection. The tip of the rib may be left undisturbed. The lumbar fascia is divided for the length of the incision, the cut being carried back to the sheath of sacro-spinalis. The external arcuate ligament is cut through with sufficient caution to avoid the pleura. Smithwick advises division of the 12th thoracic nerve and its accompanying artery. The kidney in its fascia is now held upwards and forwards while the dissection is carried over the surfaces of quadratus lumborum and psoas major to the sides of the first and second lumbar vertebræ. This is a bloodless procedure. The vertebræ are best verified by palpation and deep retractors inserted to hold the wound edges and kidney forwards and upwards. The first lumbar ganglion is quickly felt and then seen, and the sympathetic trunk followed down until the second ganglion is identified. The chain is cut through below and mobilized, as in the ordinary operation of lumbar ganglionectomy. The cut chain, still in continuity above, is held with an artery clamp while its upper end is followed to the crus of the diaphragm. It disappears beneath the internal arcuate ligament. The crus is easily cleared by finger and gauze dissection, the retractors are moved so as to exert a more upward pull, and the greater splanchnic nerve identified where it perforates the upper part of the crus. The nerve often appears as several strands close together, all coming through the same opening, distinctly above and rather external to the lumbar chain, and ending after a course of about 2 cm. in the cœliac ganglion. If the internal arcuate ligament and the crus of the diaphragm are incised upwards with a round-ended tenotomy knife, using the lumbar ganglionated chain as a guide, both that chain and the greater splanchnic can be followed up above the diaphragm. Moreover, the lesser and least splanchnics come into view very clearly

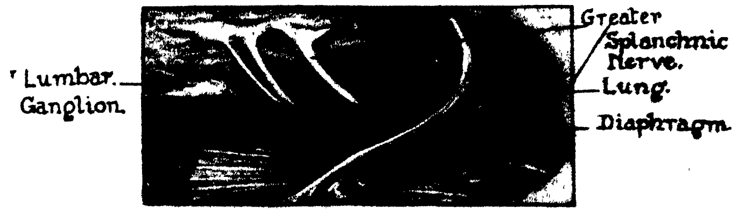

Fig. 868.—Splanchnic sympathectomy. Smithwick operation, left side, before division of diaphragm and crus, showing the three splanchnics.

as they run along the body of the 12th thoracic vertebra (Ross). (Fig. 868.) The advantage of carrying this dissection so high from below is that the line where the diaphragm should be divided now becomes plain ; further, the nerve trunks, already isolated and clearly identified below, can be discovered without loss of time in the posterior mediastinum. The surgeon now turns to the thoracic dissection by pushing the pleura off the diaphragm in the inner two or three inches of its posterior extent. This may be easily done, but it is often difficult to mobilize the pleura rapidly. Finger dissection carefully used is the safest method, aiming at the side of the 11th thoracic vertebra and, when that is reached, freeing the pleura as high as possible. The four nerves which still remain to be divided superiorly are followed as high as possible. The ganglionated trunk is sectioned opposite the 9th body, but the three splanchnics, which are more mobile, can be freed higher ; the main nerve may be cut, in favourable circumstances, at mid-thoracic level. (Fig. 869). Hæmorrhage is best controlled by silver clips or diathermy ; the vessels are always small but they are always deep. Bleeding is unimportant as a rule in any part of the operation. The wound is closed without drainage in the usual manner.

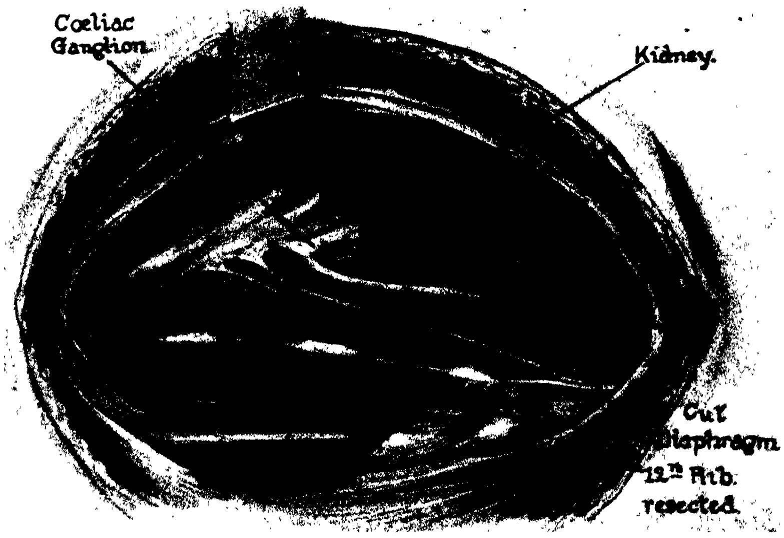

Fig. 869.—Splanchnic sympathectomy. The complete field dissected out and diaphragm divided.

Modification.—The division of the crus of the diaphragm in the line of the lumbar ganglionated chain up to and above the perforation of the greater splanchnic nerve, suggested by Paterson Ross, is an excellent innovation, as I can testify. It allows much greater certainty in the identification of structures, and very possibly it may be sufficient to limit the operation to this sub- and trans-diaphragmatic field if a good length of the greater splanchnic can be freed. There is no doubt that as much of the lumbar chain and the two smaller splanchnics can be removed as is desirable. The only possible objection is the length of greater splanchnic that can be extirpated ; this must be an incentive to the operator to secure as much of it as he can. (Fig. 870.)

Fig. 870.—Ross's modification : long incision of crus to allow good access to the splanchnics from below.

The operation is an improvement on the Craig-Adson technique since it is more radical without adding anything to the severity or difficulty of the procedure. It is not possible to divide the branches which the greater splanchnic gives to the aorta in the lower part of the thorax by this approach ; they can only be cut by the full Smithwick procedure. Opinion to-day strongly favours the Smithwick operation as being that most likely to cause a substantial fall in blood pressure. Peet still adheres to his supra-diaphragmatic method, having now over 1,000 operations to his credit. He claims that his technique does not cause sterility in males, and possibly it suffices for the milder cases.

Mortality.—The mortality of these splanchnic resections is remarkably low (2 to 3 per cent). The causes of death are usually coronary infarction or some cerebral accident (hæmorrhage or anoxia).

CHAPTER XL

GYNÆCOLOGICAL OPERATIONS

By L. C. RIVETT

INTRODUCTION

THE operations of gynæcological surgery are by custom divided into :—

(1) Operations on or through the external genitalia.
(2) Operations through the anterior abdominal wall.

At times a combination of both routes may be used at the same time on the same patient.

The preparation of the patient for a gynæcological operation includes a number of special considerations, and the foremost of them is due to the fact that the law allows not only the woman, but her husband, if she has one, a proprietary right in her organs of generation. It is therefore important to obtain the sanction of both parties before any important organ is removed. A certain amount of discretion must be used, especially when dealing with highly-strung or neurotic women, not unduly to alarm the patient. Especial care should be taken in obtaining permission to perform an operation simply and solely for the purpose of sterilization. The written consent of both parties should always be obtained. When the essential organs of generation are removed for disease, it is in many cases advisable to explain that the disease has already rendered the patient infertile and that the operation is to remove diseased organs which anyway would not function. Operations which occlude the vagina, such as Le Fort's operation for prolapse, should only be performed in an elderly widow or in a married woman whose husband is made fully aware of the fact that intercourse will henceforth be impossible.

It is general practice to withhold as far as possible from any patient the fact that she is suffering from any form of cancer, but in all cases it is advisable that her nearest relatives be fully informed of the nature of the disease, if only to guard the surgeon against recrimination should recurrence take place later.

It is inadvisable to perform certain operations during menstruation, particularly plastic operations, as the hyperæmia will cause considerably more bleeding than would have been the case in the intermenstrual phase. Even more is this important for the operation of myomectomy. On the other hand, hysterectomy, operations on ovarian tumours, and inflammatory lesions may be undertaken during menstruation as, in some cases, particularly with sloughing fibroids, the intervals between uterine bleeding are so short that it is inadvisable to delay the operation, as the patient is losing still more blood and is already anæmic.

Preparation of the bowels.—This has special importance in gynæcological operations, as an incompletely emptied rectum, full of watery fæcal material, in close proximity to the operation area is obviously undesirable. If an aperient is needed at all, it should be given at least forty-eight hours before the operation and, if it does not act satisfactorily, emptying of the bowel may be assisted by an enema not less than twelve hours before the operation.

Preparation of the bladder.—In all gynæcological operations it is extremely important that the bladder be empty. It must be borne in mind that many gynæcological complaints in themselves render complete emptying difficult. It is therefore advisable that, as a routine, the bladder should be emptied by catheter immediately before operation. If several operations are being done at a session, it will be found very useful to have the catheter passed while the patient is in the ward, and left in the urethra while she is taken to the anæsthetic room and anæsthetized, as sometimes a patient has to wait ten or fifteen minutes in the anæsthetic room and during that short time may produce a surprisingly large secretion from the kidneys.

Pre-anæsthetic medication.—Pre-operative medication is greatly on the increase. In gynæcology it is particularly important to take into consideration not only the usual nervousness of the patient, but also the special operation to be performed. The administration per rectum of drugs such as avertin is not advisable before an operation on the perineum, as some of the solution is likely to escape during the operation and, being contaminated with fæces, to infect the operation area.

Wertheim's hysterectomy involves much dissection of tissues and consequent shock, and it is a very common practice to give a spinal anæsthetic, as a nerve block, combined with a general anæsthetic. It is inadvisable to use a spinal alone for an operation which takes as long as a Wertheim, with the patient in the full Trendelenburg position, as not infrequently a conscious patient will get a feeling of nausea, and retch, if not actually vomit, at a most critical stage of the operation.

Apart from these considerations, the choice of premedication must depend upon the temperament of the patient and the practice of the anæsthetist.

Preparation for a perineal or vaginal operation.—The labia majora, mons Veneris, and inner and posterior aspects of the thighs should be shaved, and the whole area well cleaned with soap and water, rinsed, and dried with sterile wool. It should then be swabbed with surgical spirit and again dried. Ether soap and ether are apt to sting and burn the labia, and are best avoided. The whole area is then painted with an antiseptic solution. Tinct. iodi. mitis is a favourite, but in some women causes intense burning of the vulva for several days. Violet green solution (Bonney's blue paint) is excellent for the purpose, and does not cause irritation or burning. The whole area is covered with aseptic dressing, and the painting can be repeated immediately before the operation.

Preparation of vagina.—Before any operation involving the vagina, two antiseptic douches should be given : the first one about twelve hours, and the second one an hour, before the operation. When the patient is under the anæsthetic and in the lithotomy position, the vagina can be further cleansed. Some advocate thorough washing with soap and water, but swabbing with an antiseptic is usually efficacious. Here again, iodine is very likely to cause irritation and burning. Violet green solution is good, but has the disadvantage, by reason of its colour, that the operation area, particularly the vault of the vagina, may be very hard to see. Surgical spirit is almost equally efficacious, and has neither of these disadvantages.

Abdominal preparation.—The skin of the whole of the anterior abdominal wall, as far out as the anterior superior iliac spines and from the ensiform cartilage to the pubes, should be shaved. The shaving should be carried down to include the labia majora. The whole area should be washed with soap and water, rinsed, and dried with sterile wool, and then washed again with ether soap. The ether soap is cleaned off with acetone and ether, and the whole area painted with antiseptic solution such as tinct. iodi. mitis, 2 per cent. picric acid in spirit, or violet green solution. If violet green solution is used, three applications should be made, allowing the solution to dry in between each application. After painting, the whole area is covered with aseptic dressings which are left in place until the patient is in position on the table.

Vaginal preparation.—If the abdominal operation is to involve opening the vagina, this should receive the same treatment as has been described for vaginal operations. If the vagina is not to be opened, no special preparation is required.

For a Wertheim's hysterectomy, a special preparation is fully described on p. 1860.

Post-operative treatment.—When the patient is brought back from the operating theatre, she should be put into a bed which has been thoroughly warmed, but from which all hot water bottles have been removed. An anæsthetized patient is very easily burned by a hot water bottle, even if it is well covered and protected, as the damage is not truly a " burn," but necrosis due to the altered condition of the neuro-muscular mechanism of the cardio-vascular system.

The nurse should be in constant attendance, to guard against cyanosis due to vomiting or " swallowing tongue." When the patient comes round from the anæsthetic, the hypodermic administration of morphia gr. ⅙ or heroin gr. ⅛ is useful to allay restlessness and stop pain. This injection may be repeated six to eight hours later if necessary.

Shock.—It is only after large operations that there is any appreciable shock nowadays, but there is sometimes a certain amount after the removal of very large tumours, and particularly after a Wertheim's hysterectomy. Shock sometimes follows an operation during which there has been an excessive loss of blood, particularly an extensive myomectomy, and in some cases of ectopic gestation (when the blood has really been lost before the operation), and in severe menorrhagia, when the loss of blood before operation has been so great as to cause a marked secondary anæmia.

A mild degree of shock is well treated by giving ten ounces of 6 per cent. glucose in saline per rectum. If it is given within half an hour of the end of the operation, it is usually retained and rapidly absorbed.

Patients suffering from more marked shock or anæmia are sometimes best treated by intravenous medication. Intravenous saline will do much to combat shock, and a pint run in by the drip method at forty drops per minute is very valuable in some cases. For the most severe cases, and as a routine after Wertheim's hysterectomy, a blood transfusion is infinitely preferable, and one or even two pints administered by the continuous drip method of Marriott and Kekwick has completely changed the operation · mortality-rate of Wertheim's hysterectomy.

Catheterization.—After any gynæcological operation, particularly after an operation on the perineum, the function of the bladder is apt to be disturbed, and the patient is unable to pass urine spontaneously. It is a very common nursing fault to withhold the catheter. It is most harmful to allow the bladder to get over-distended in a mistaken hope that, if the patient is left long enough, she will void urine herself. If the patient has failed to pass urine within twelve to sixteen hours of the operation, the catheter should be passed as a routine, and it should be passed before this time if there is any evidence that a quantity of urine is collecting in the bladder ; and, thereafter, unless the patient passes urine spontaneously, the catheter should be passed as soon as it is estimated that ten ounces will have collected. A fair estimation can usually be made by keeping a record of the amount of fluid the patient has drunk.

This point is of particular importance after a Wertheim's hysterectomy. During the course of this operation, most of the blood supply of the bladder is cut off, and a great deal of the bladder is dissected from the surrounding tissues, and the resulting paralysis is likely to last at least two or three weeks, and frequently it is six weeks before the bladder has completely regained its tone. When a patient who has had Wertheim's hysterectomy does pass urine spontaneously, a catheter should be passed immediately after the act, when several ounces of residual urine will be found, and it is most important to draw off this residual urine each time. If it is left in the bladder, it not only lengthens the time taken by the bladder to regain its tone, but also tends to infect the bladder, and the infection is very apt to spread up the ureters to the pelvis of the kidney and give rise to a very serious pyelonephritis.

When an operation has actually involved the bladder or urethra, it is advisable to drain the bladder. If the damage has been small, it is sufficient to insert a self-retaining catheter, which is left draining into a bottle under the bed for two to ten days. In more extensive cases, suprapubic draining with continuous suction is preferable. (See Operations on the Bladder, p. 1984.)

Post-anæsthetic vomiting is not usually serious after gynæcological operations, and requires no special mention.

Flatulent distention of the colon is, however, common after some pelvic operations, as the sigmoid colon may be considerably disturbed, owing to its proximity to the left ovarian pedicle. Flatulent distention is particularly apt to occur after a Cæsarean section, though it is very difficult to explain why. It is probably often due to incomplete hæmostasis. Another possible factor is the atony of the abdominal wall. The treatment is early evacuation of the bowels, and in most cases an aperient can be given about thirty-six hours after the operation. If it has not acted within twelve hours a simple enema may be given. If distention persists, the injection of 1 c.c. of posterior pituitary extract or 1 c.c. of acetylcholine, followed by a turpentine or ox-gall enema, is sure to be efficacious.

Posture.—It is the custom to nurse cases after a pelvic operation in the Fowler position. It is not necessary to be at all strict, and a patient should be allowed to change her position and spend some of the day and most of the night flat, and be in a Fowler position during part of the day only. After an operation on the perineum, the Fowler position is most uncomfortable, and patients should always be nursed fairly flat, with just sufficient pillows for comfort, for at least a fortnight.

The spinal anæsthetic commonly used as a nerve block at Wertheim's hysterectomy is of low specific gravity, so that it floats on the cerebrospinal fluid. It is therefore important that the patient should be kept in the Trendelenburg position for twelve hours after the operation, and thereafter nursed as for abdomino-pelvic operations.

Diet.—There are no special points about diet. It is quite unnecessary to urge the patient to eat, and a very light diet is preferable until she actually demands more.

Removal of sutures.—Superficial skin sutures should be removed on the fifth or sixth day after the operation. If through and through silkworm gut sutures have been used, they should be left until the tenth day. In most gynæcological abdominal operations, the dressing is very unimportant, and hospital cases are quite satisfactory with no dressing at all. Many women, however, feel the need of a fairly firm abdominal binder, and a many-tailed is most satisfactory. After the stitches have been removed the wound can either be left alone or covered with a collodion dressing.

Perineal operations.—After operations on the vagina and perineum, a sterile pad is placed over the parts and, after every act of micturition or evacuation of the bowels, the perineum and the vagina should be gently swabbed with cotton wool soaked in a weak antiseptic solution, and then carefully dried. It is especially important gently to pass a piece of cotton wool held by forceps right into the vagina as, when a patient is lying on her back, fluid is apt to accumulate in the vagina and delay healing.

After-care.—Many parous women have very poor abdominal muscular control, and divarication of the recti abdominis muscles occurs frequently. After an abdominal operation, such patients may require some form of abdominal support. The exact form can only be determined by a study of the general build of the patient, as well as the site and extent of the scar.

I. OPERATIONS ON THE VULVA

REMOVAL OF URETHRAL CARUNCLE

The urethral caruncle may be treated by direct cauterization. The patient is placed in the lithotomy position in a good light, the labia are held apart with the thumb and forefinger of the left hand, and the cautery, at a dull red heat, is applied to the posterior part of the urethral meatus, burning away the caruncle and the underlying part of the urethral mucosa. The heat prevents bleeding, and healing is usually straightforward.

Caruncles are apt to recur, and a more complete cure is obtained if the lower end of the urethra which bears Skene's tubules is removed by dissection. The incision encircles the external urinary meatus and extends posteriorly about ¼in. beyond it, and by dissection about ½in. of the urethra, together with the tissue immediately posterior to it, is freed. It is then cut half-way through from the posterior aspect, and two or three sutures of fine catgut are used to anchor the cut edge of the urethral mucosa to the skin of the vestibule. The anterior part is then cut through, and two or three more sutures inserted. These sutures usually stop all bleeding, and there is rarely any trouble with micturition after the operation.

REMOVAL OF BARTHOLIN CYST OR ABSCESS

The patient being in the lithotomy position, a vertical incision is made over the cyst towards its inner aspect. The cyst wall is recognized by its translucency, and when it is reached, the tissues on either side are separated from its surface by light touches of the knife, assisted by blunt dissection, for which purpose the handle of the scalpel answers very well. It facilitates removal if the cyst can be got out unbroken. On its vaginal aspect the covering tissues are very thin. On the outer side and behind it a few small vessels will be severed, and any bleeding points that are seen should be picked up and, when the cyst has been removed, should be ligatured. Two or three catgut sutures should then be deeply passed from side to side and buried under the floor of the cyst cavity ; the skin is not included. When they are tied, they close the gap and check oozing. Venous oozing may be very troublesome, and cannot be controlled by simple ligatures, as it comes from the cavernous tissue in the labia majora. Lastly, the skin edges are united by a continuous suture of fine catgut. As a rule, no drainage is required, but if there is a tendency to oozing, a small gauze wick can be left in for twenty-four hours. The advantage of catgut for uniting cut edges of mucous membrane and skin in all plastic operations about the vagina and vulva is that there are no stitches to be removed later. This is a matter of importance, as the removal of stitches in this position is a source of considerable apprehension and discomfort to the patient.

The procedure for dissecting out a Bartholin **abscess** is the same as for a cyst, but it is more difficult because the tissues are matted together, and the abscess does not "shell out" as does a cyst. With a large acute abscess, it is generally better to incise in the first instance, the dissection being postponed to a later date, when infection will be less virulent and the parts will have contracted a good deal.

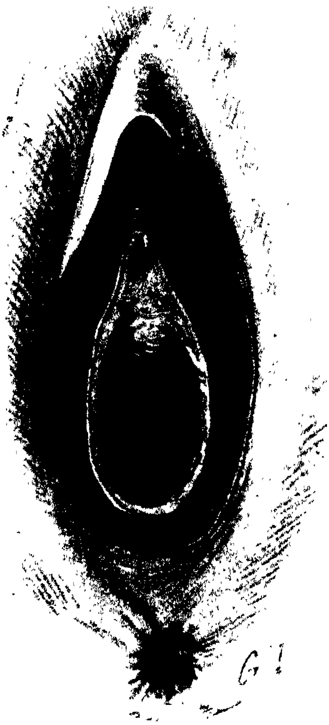

Fig. 871.—Excision of vulva for leucoplakia, showing area to be excised.

REMOVAL OF INNOCENT TUMOURS FROM THE VULVA

Sebaceous cysts, fibromata, and papillomata may have to be removed. The principles to be observed are : an incision so planned as to be clear of the growth, hæmostasis, and suturing without tension.

EXCISION OF VULVA FOR LEUCOPLAKIA

Two incisions are made, as shown in Fig. 871. The inner one starts in front of the urethral orifice and passes backwards just within the margin of the vaginal orifice. It crosses the middle line in front of the fourchette, and runs forwards again just within the line of the vulvo-vaginal margin, to join the first part of the incision in front of the urethra. The second or outer incision starts in front of the preputial folds of the clitoris and passes backwards along the outer border of the labium majus. It crosses the perineum, either just behind the fourchette or farther back, according to the extent of the disease, then turns forwards along the outer border of the other labium majus and joins the first part of the incision. All the cutaneous and subcutaneous tissues within the boundary lines of the two incisions are dissected off, as shown in Fig. 871. Bleeding points should be picked up and tied.

The first step in suturing this wound is to anchor the urethral orifice to the skin. A point is chosen on the left side of the patient, where the skin will easily come in contact with the urethral orifice. A suture is passed through the skin at this point and is then passed through the skin surrounding the urethra at its anterior margin. It is then passed through the skin of the right side of the wound, and tied.

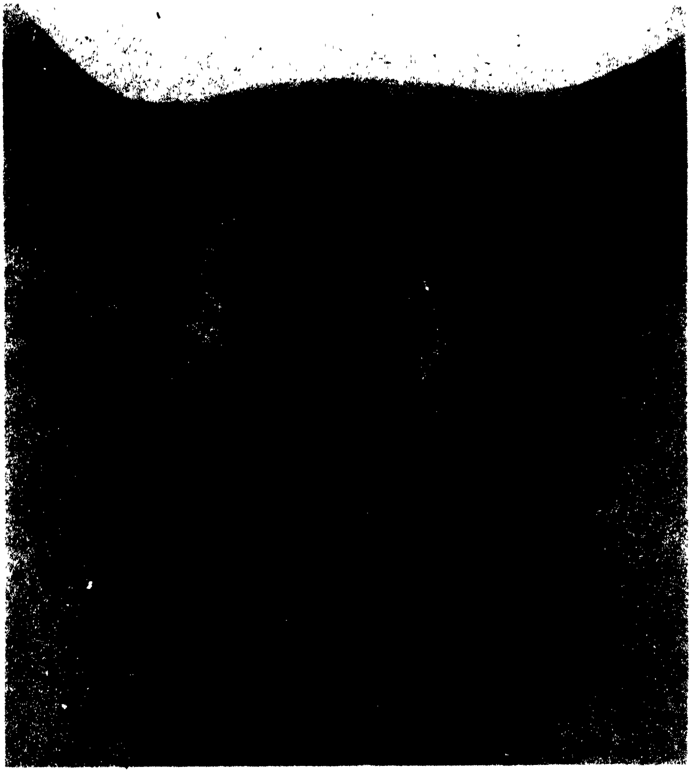

Fig. 872.—The dotted lines show incisions for complete excision of vulva and glands in groin. The incisions in the groin are made with the patient on her back : the incisions round the vulva with the patient in the lithotomy position.

The second suture is placed about ¼ in. posterior, through the skin of the left flap and through the skin at the posterior edge of the urethral orifice, and tied. A similar suture is passed on the right side. The two edges of skin anterior to the urethral orifice are then united by a series of interrupted sutures. The skin of the rest of the wound has now to be united to the vaginal margin, which is best done by a series of interrupted sutures ; they should be inserted alternately on the left and right side of the incision until the whole wound is closed. (Fig. 874.)

EXCISION OF VULVA FOR EPITHELIOMA

In excision of the vulva for epithelioma, in all but the earliest cases, it is necessary to remove the inguinal glands, and the whole lymphatic area should be removed in one piece with the vulva.

The operation is commenced with the patient on her back. An incision is made about 1 in. above Poupart's ligament from the anterior superior spine to the mons Veneris, almost to the middle line, and the skin and immediate subcutaneous tissue is dissected up for about 2 in. on either side of this incision. The fatty subcutaneous tissue containing glands and lymphatics is dissected off the fascia covering the external oblique muscle, commencing at the upper outer region and proceeding towards the middle line. Bleeding points are secured and the mass of tissue is turned inwards and downwards so that it lies on the towel covering the space between the thighs. The skin incision is closed to the middle line, either by interrupted or a continuous suture. A similar dissection is carried out on the opposite side until it meets the first dissection in the middle line. The patient is then put into the lithotomy position and, starting at the lower end of the two incisions, an incision is carried widely around the vulva, removing the whole of the labia majora and ending in the middle line just clear of the anal margin (Fig. 872).

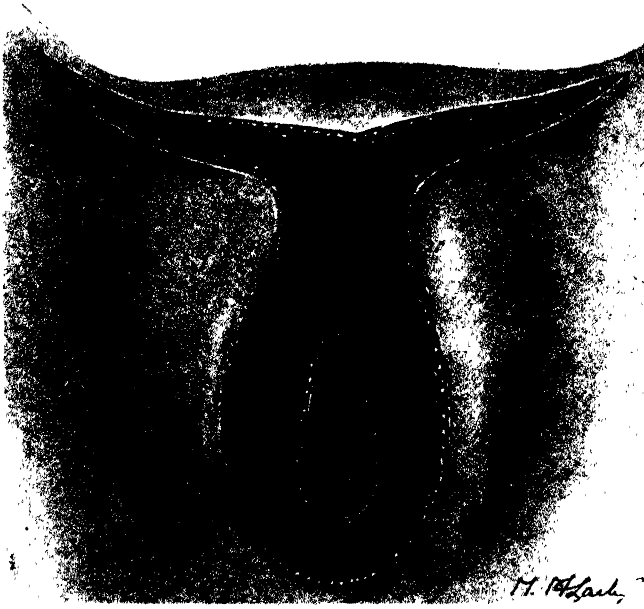

Fig. 873.—Excision of vulva.

A second incision is made round the urethral and vaginal orifices as described above, and the operation proceeds as for simple excision (Fig. 873), except that, owing to the wider removal of tissue, the two skin flaps will be united to each other for an inch or more behind the vaginal orifice (Fig. 874).

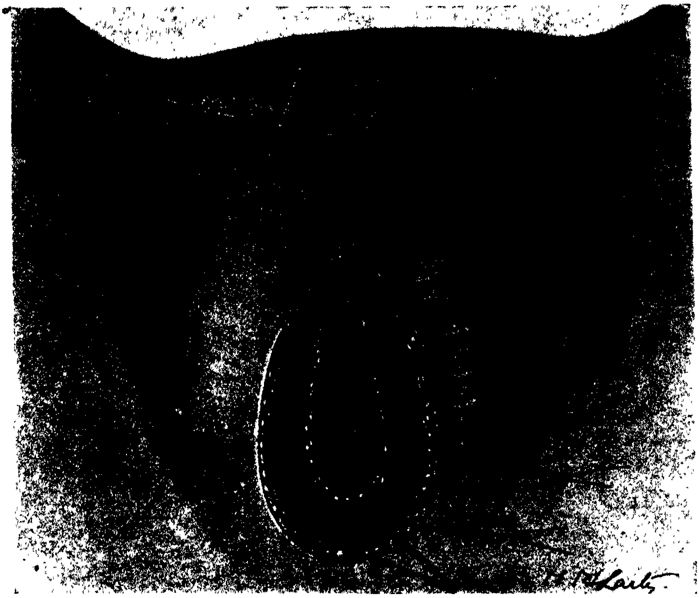

Fig. 874.—Methods of inserting sutures.

II. OPERATIONS ON THE VAGINA

EXCISION OF HYMEN AND ENLARGING VAGINAL ORIFICE

The patient is placed in the lithotomy position and the labia are separated. The hymen is seized with tissue forceps at two points, one on each side, approximately where the lateral walls of the vagina join the posterior wall. Each tissue forceps is held by assistants so that the posterior edge of the hymen is everted, and the portion between the forceps is cut off with scissors. The free edge of the posterior vaginal wall is dissected up for about half an inch, and an incision is then made antero-posteriorly into the superficial muscles of the perineal body and skin of the perineum, just sufficient to enlarge the orifice to the required extent (Fig. 875). The flap of posterior vaginal wall is then sutured to the cut edges of the perineal skin to cover the raw area completely (Fig. 876).

This method is infinitely preferable to digital stretching and tearing of the vaginal orifice, as it leaves no small tags of hymen which, if left, may subsequently give rise to as great a degree of dyspareunia as the original small orifice.

HÆMATOCOLPOS

The patient is placed in the lithotomy position ; the bulging purple septum is incised with a crucial incision, and the fluid allowed to escape. As a rule, no other treatment is required.

REMOVAL OF CYSTS AND INNOCENT TUMOURS

Cysts from embryonic remnants are sometimes found in the vagina. Solid tumours are extremely rare. In either case, the operation for the removal of a simple tumour is carried out with the patient in the lithotomy position, and an appropriate retractor is used to expose the cyst. If the cyst is in the anterior or lateral wall, an Auvard's speculum is satisfactory, but if the cyst is in the posterior wall, other retractors must be improvized to give exposure.

Fig. 875.—Dissecting up flap of vaginal mucosa and incising tissues of perineum.

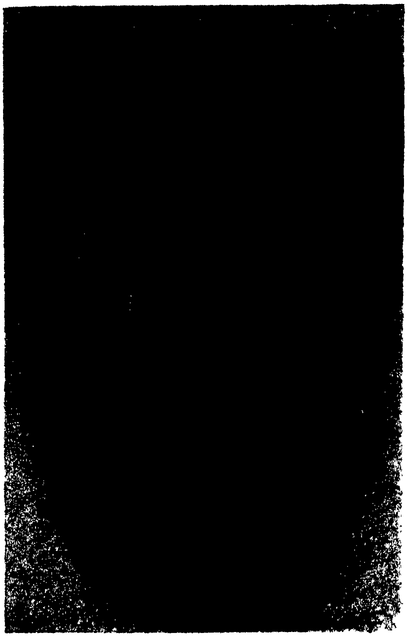

Fig. 876.—The enlarged vaginal orifice sutured.

The removal does not present any difficulty. An incision is made over the tumour and it is dissected out by blunt dissection, bleeding points secured, and the vaginal skin sutured with a continuous catgut suture.

ATRESIA OF THE VAGINA

Atresia of the vagina may be congenital or it may follow trauma in connection with childbirth, or an operation. Great difficulty may be experienced in dealing with a stricture, as there is very likely to be a great deal of very dense scar tissue which, by cicatricial contraction, has drawn branches from the internal pudic artery away from the side wall of the pelvis into such a position that they may cause very troublesome hæmorrhage when the scar tissue is incised.

In favourable cases, a longitudinal incision is made posteriorly, and sutured transversely. In unfavourable cases it may be impossible to obtain any improvement. Such cases sometimes respond to prolonged treatment with graduated dilators.

For Congenital Absence of Vagina

Several operations have been devised to make an artificial passage in cases of congenital absence of the vagina. Heretofore, the most successful operations have utilized a portion of the bowel as a graft with considerable success. The operation, however, is of necessity severe, as it entails resection of gut. Attempts to build a tubular flap of skin, and to graft it attached to a pedicle have not been very successful.

Recently a new method has been devised whereby a large half-skin graft is wrapped round a vulcanite mould, which is inserted into a space dissected between the rectum and the bladder, and allowed to remain there, not only while the graft takes, but until it is unlikely that cicatricial contraction will take place. This operation is simple ; in fact the only point of the whole operation is getting the graft as, in order to be successful, it is necessary to have in one piece a skin graft measuring at least 8 in. × 4 in. An area of skin on the thigh is prepared as for a surgical operation and covered with a sterile dressing and bandage. The patient is placed in the lithotomy position and a verticla incision about 1 in. long is made, commencing just behind the urethral orifice, and extending towards the rectum. Blunt dissection with the tip of the gloved finger is usually quite easy. The dissection is carried out as far as the finger will go, and then is widened by the insertion of two fingers.

It is well to have prepared two or three vulcanite moulds of different sizes, and the most appropriate-sized one is put into the space already made in the perineum. The mould should pass easily into the space, and should lie just deep to the skin edge of the first incision. To get the mould out, two fingers are placed in the rectum and the other hand on the abdominal wall above the symphisis pubis, when it will be found quite easy to manipulate from the incision. The space in the perineum is lightly packed with gauze and the patient put flat, and the skin graft cut. The mould is cleansed, dried, and painted with a solution of Mastisol,* and the skin graft carefully applied, care being taken to put the external surface of the skin in contact with the mould, so that the cut surface will be in contact with the raw area in the perineum. The mould, covered with skin, is now inserted into the space in the perineum and a few sutures are inserted to join the skin edges of the original incision, leaving a small opening anteriorly to allow the escape of any serum or pus which forms around the mould. The mould is left *in situ* for six months, and then removed. For its removal, the skin covering it should be dealt with exactly as described in the operation for excision of hymen. The mould is withdrawn and thereafter vaginal dilators should be used for a month, to make sure that there is no cicatricial contraction at the orifice.

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* *Mastisol:* Mastich pulv., 2 lbs. ; Ol. ricini, 1½ ozs. ; Benzene to ½ gall. Add the mastich to the benzene to 60 ozs. in 100-oz. dry wide-mouthed bottle, and macerate for three days. Shake well and filter through paper. Add the castor oil and the benzene to volume.

LE FORT'S OPERATION

This operation is only suitable for widows well past the menopause, as it really consists of obliteration of the vagina. It can only be used in cases of complete procidentia.

The cervix must be held well down with volsellum forceps and a large area of the vaginal mucosa mapped out on the anterior wall. The mucosa is dissected off this area, and bleeding points on the raw site secured. A similar area is mapped out on the posterior vaginal wall and dealt with in the same way. These two areas should be planned to leave a strip of vaginal mucosa about an inch wide on each side. A long continuous suture is placed at the apex of the raw area, through the edge of what is left of the vaginal mucosa in the middle line close to the cervix, and it is tied so that each end is of equal length. The needle is kept on the first end and a second needle threaded on to the other end. One needle is now passed through the edge of the apex of the posterior flap and two or three continuous stitches are made. This needle is then held by an assistant, and the other needle is used to come down the opposite side, stitching together the cut edges of the anterior and posterior flaps and, by a series of a few stitches at a time, the continuous suture is carried on until it reaches the vulva. It will then be found that the two raw areas are in apposition and that the two strips of mucosa have formed a narrow tunnel from the vulva to the cervix. It is usually quite easy to define the levator ani muscles and to complete the perineorrhaphy in the ordinary way.

PLASTIC OPERATIONS FOR PROLAPSE

Repair of cystocele.—This operation consists of dissecting the vaginal mucous membrane from the pubo-cervical fascia, pleating the pubo-cervical fascia, and removing redundant vaginal mucosa.

The patient is placed in the lithotomy position and an Auvard self-retaining speculum put in the vagina. The cervix is exposed, seized by volsellum forceps, and pulled down and held by an assistant. The surgeon seizes the vaginal mucosa at a point about one inch from the external os, and lifts it up to ascertain the junction between that part of the vaginal mucosa which is firmly attached to the cervix and that part which is really the reflection to the anterior fornix. It will be found that the mucosa can be raised up to give the appearance of a frenum. This frenum is snipped with scissors, and a blunt dissector—appropriately, the closed blades of round-nosed scissors—can be inserted into the plane of cleavage between the vaginal mucosa and pubo-cervical fascia. Blunt dissection must be carried out right to the margin of the urethral orifice.

In an extensive cystocele, it may be easier to do this dissection in two stages, dissecting about half-way and then slitting up the anterior mucosa as far as the dissection has gone, seizing the edges with tissue forceps and, from this fresh point of traction, continuing the blunt dissection. The anterior vaginal wall is then slit up throughout the entire length, right to the margin of the urethral orifice, and tissue forceps placed on the cut edges, which are held apart by assistants. With a swab, the pubo-cervical fascia can easily be separated from the vaginal mucosa, well to the sides of the cystocele. This dissection is sometimes facilitated by a series of snips with the points of the scissors, just under the margin of the cut vaginal edge. When the pubo-cervical fascia has thus been exposed, a series of sutures—either interrupted or continuous—of the Lembert type are placed in the pubo-cervical fascia, the first stitch being placed at the urethral end of the incision as far out on the left side as possible. The needle is then passed in a similar position on the right side, the intervening tissue depressed, and the suture tied. The next suture is a little lower on the left side, and similarly on the right, until the suture line reaches the cervical end of the incision. The redundant vaginal mucosa is cut away, and the edges united by continuous or interrupted suture.

Fothergill's operation.—This operation consists of amputation of the cervix, exposure of the pubo-cervical fascia as in the treatment of cystocele, suture of the lateral cervical tissue in front of the cervix, and repair of the anterior vaginal wall. In certain cases of prolapse it is almost the ideal method of treatment, and the points to be observed in order to decide if the type of prolapse is suitable are as follows :

(1) it must be possible to draw the anterior vaginal wall completely out of the vulva ;
(2) there must be firm anchorage of the lateral vaginal fornices, and
(3) the cervical canal must be elongated.

The patient is placed in the lithotomy position, an Auvard's speculum placed in the vagina, and the cervix seized with volsellum forceps and drawn out of the vulva. The cervix is dilated by the passage of three or four graduated dilators, to facilitate the subsequent passage of sutures. The lateral vaginal mass is defined through the vaginal mucosa and seized on either side by tissue forceps as far out from the cervix as is judged will meet in front of the reconstructed cervix and give it support. With a scalpel, an incision is made from close to the margin of the urethral orifice, extending down the side wall of the vagina to just medial to the tissue forceps on the lateral vaginal masses, and then around the posterior lip of the cervix and up the lateral wall of the vagina to the urethral orifice (Fig. 877). The apex of the flap near the urethral orifice is seized and the area of vaginal mucosa defined by the incisions is dissected off the pubo-cervical fascia until the cervix is reached (Fig. 878). The bladder must next be dissected off the cervix. The dissection can be started by making a few snips with the scissors and completed by blunt dissection with the aid of a swab. When sufficient cervix is exposed in front, the dissection is completed round the cervix in order to raise lateral and posterior flaps. In the posterior dissection, care should be taken not to open the peritoneum of the pouch of Douglas. The cervix is then cut through with a scalpel. During this manœuvre, the anterior edge of the cervical stump is seized with volsellum forceps to prevent the uterus from retracting. The amputation of the cervix is then completed. A catgut suture is placed through the posterior lip of the stump of the cervix in the midline (Fig. 879) and continued through the posterior flap of vaginal mucosa and tied, so as to bring the vaginal mucosa in contact with the mucosa of the cervical canal. A similar suture is next placed in the lateral angle of the stump of the cervix and passed through the vaginal mucosa in such a position that it will cover the postero-lateral quadrant of the stump and meet the mucosa of the cervical canal as before. This manœuvre is repeated on the opposite

Fig. 877.—Dissecting off anterior vaginal flap.

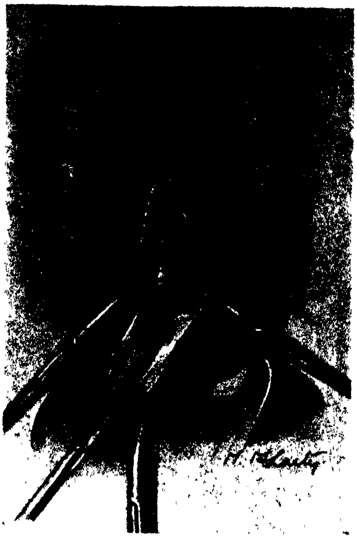

Fig. 878.—The anterior vaginal flap dissected off.

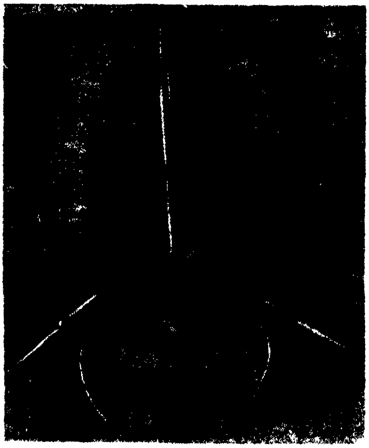

Fig. 879.—Inserting the first suture.

side. The next suture is a complicated one, aimed to fix the lateral vaginal masses to the anterior portion of the stump of the cervix and to each other. The needle is first passed through the lateral vaginal mass of one side, which has been picked up with tissue forceps, and then through the stump of the cervix from the anterior surface of the stump into the cervical canal. The needle is next passed back again from the cervical canal through the cervix to the anterior surface of the stump and then through the lateral vaginal mass on the opposite side (Fig. 880). This suture should be of stout catgut, as it requires considerable strain to bring the lateral masses together in the middle line. When it has been tied, the ends should be held in Spencer-Wells forceps and used as a tractor. Another stout suture is now inserted.

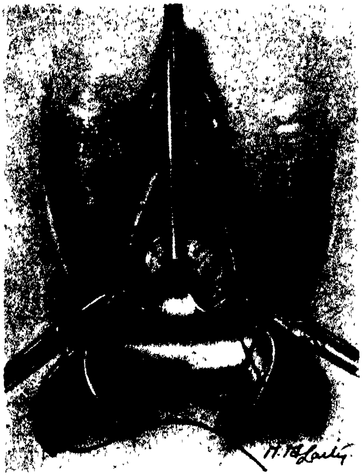

Fig. 880.—The suture to bring the vaginal angles to the anterior part of the cervix.

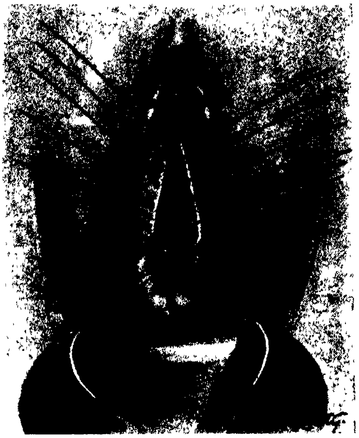

Fig. 881.—The sutures in the anterior vaginal wall.

It begins about a quarter of an inch nearer the urethra than the first suture, passes through the vaginal mucosa on one side, through the substance of the anterior portion of the cervical stump—not encroaching on the cervical mucosa—and out through the vaginal mucosa of the opposite side. This suture further fixes the vaginal mucosa to the stump of the cervix. The ends are held in Spencer-Wells forceps and the first suture may now be cut, starting from this suture, and this one used as tractor. A series of catgut sutures are then put into the flap, gradually approaching the urethral orifice, and so closing the incision (Fig. 881). This operation should always be followed by a perineorrhaphy.

OPERATIONS FOR FISTULA

Vesico-vaginal fistula.—Operations for the cure of a vesico-vaginal fistula must of necessity be varied according to the extent of the damage to be repaired and the actual site of the fistula. The principles employed are, mainly, separation of the vaginal wall from the bladder wall, removal of scar tissue from the edges, and an endeavour to suture healthy tissue to healthy tissue, with as big a space as possible between the suture line in the vaginal wall and the suture line in the bladder wall.

A small fistula which is easily accessible can be repaired from the vagina, especially if there is not much scar tissue and the vaginal wall near the fistula can be mobilized on the subjacent structures. The vaginal wall should be seized with tissue forceps in two or three places, each about half an inch from the edge of the fistula, the tissue forceps being so placed that, when held by assistants, a good view of the fistula is obtained by the surgeon. The very edge of the fistula is then picked up with a fine notched dissecting forceps and, with a slender pair of curved scissors, a series of snips is made round the opening to free the bladder mucosa from the vagina. The opening into the bladder can then be closed by a fine catgut suture on a small curved needle. The ends of this suture should be left long and held out of the way; they will be found useful later to identify the site of the fistula.

The dissection of vaginal flaps is now continued away from the fistula until about half an inch of vagina has been denuded. Oozing from this raw area is controlled and the closure made more secure by placing a purse-string suture in the raw tissue about a quarter of an inch from the actual fistula and invaginating the suture which actually closed the fistula as this purse-string suture is tied. The freed portion of the vaginal mucosa is trimmed away and the vaginal mucosa carefully sutured, so completing the operation.

In more extensive fistulæ, it may be impossible to bring the actual fistula well into view, in which case an incision should be made in the vaginal mucosa half an inch or more from the fistula, and the mucosa dissected up towards the fistula instead of away from it. When a sufficient area has been cleared, a purse-string suture can be inserted as described above, followed by closure of the vaginal incision, and the bladder opened by a suprapubic exposure, the bladder mucosa trimmed and sutured with fine catgut from within the bladder. (See p. 2031.)

When there is much scarring, all the bladder mucosa may be so immobilized that it may require much ingenuity to find any tissue to dissect, or to make any flaps at all, and an extensive scarred fistula may present one of the most formidable problems in surgery.

After the repair of any extensive fistula, it is usually advisable to drain the bladder for two or three weeks, either by a self-retaining catheter or, in more severe cases, by a suprapubic drain with suction.

Ureteric fistulæ.—Ureteric fistulæ may follow total or Wertheim's hysterectomy. In such cases, the fistula communicates with the remains of the vagina. Ureteric fistulæ may also follow labour, and then may be either uretero-vaginal or uretero-cervical fistulæ. In either case, the method of repair is similar, and depends upon the point at which the ureter is injured: if it is near the vesical end of the ureter, it is sometimes possible to define the ureter, after having opened the bladder by a suprapubic incision, without opening the peritoneal cavity. In such a case, an incision in the mucous membrane of the bladder may enable the operator to bring the proximal end of the ureter into the bladder, and to anchor it there with a few fine catgut sutures. If the injury is more lateral, it is better to open the peritoneal cavity and define the ureter as it runs between the layers of peritoneum forming the broad ligament, much as in the operation of Wertheim's hysterectomy. (See p. 1862.) The ureter is freed down to the fistula and the freed portion implanted in the upper angle of the bladder. For this purpose, the bladder itself must be opened and the free end of the ureter anchored with fine catgut sutures. (See pp. 1965 and 2017.)

It is usually advisable to drain the bladder through the suprapubic incision, and to apply continuous suction for ten days. When the drainage tube is removed, this opening usually closes in two days.

III. OPERATIONS ON THE PERINEUM

PERINEORRHAPHY

1. **The cure of rectocele and repair of pelvic floor.**—The patient is placed in the lithotomy position, the labia majora and minora are

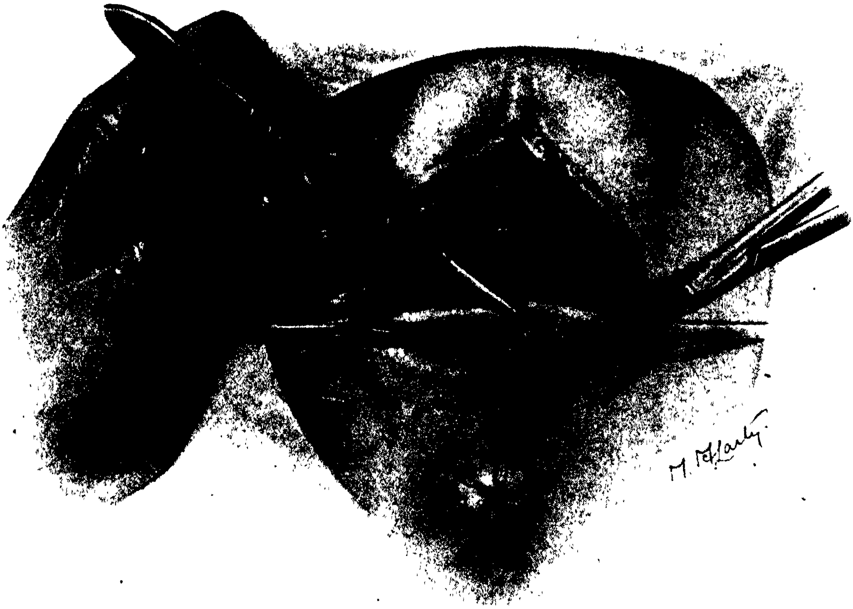

Fig. 882.—Cutting away ridge of scar tissue of perineum.

separated and the carunculæ myrtiformes defined. They end on either side at points which appear to be about the middle of the lateral wall of the vagina. Critical examination will show that the whole of the posterior edge of the vaginal opening below these points is really epithelialized scar tissue and that the points, when approximated, give the true normal vaginal orifice. These points are seized with tissue forceps which are held by assistants, who must be instructed to hold them but not pull on them, as the mucosa is very friable and easily torn. It will be found that a ridge of skin can be lifted up with the dissecting forceps between these two tissues forceps (Fig. 882), and this ridge is cut off with the scissors just sufficiently widely to remove the epithelialized scar tissue.

Fig. 883.—Dissecting up posterior vaginal flap.

Fig. 884.—Cutting off posterior vaginal flap.

The cut edge of the vagina thus exposed is picked up at its centre with dissecting forceps held in the left hand, the third finger of which is inside the vagina and pressed on to the posterior vaginal wall to act as a guide. A series of snips with the tip of a pair of round-nosed scissors is made on to the tip of the third finger, until the pearly white inner surface of the vaginal mucosa is exposed (Fig. 890, p. 1848). The dissecting forceps is then replaced by a Spencer-Wells, and it will be found that blunt dissection with the finger enters an avascular plane of cleavage just deep to the vaginal mucosa, which can be carried up the posterior vaginal wall as far as required—to the cervix, if necessary (Fig. 883). The distance this dissection is carried is determined by the amount of the posterior wall to be removed in order that the reconstructed vagina may be a parallel cylindrical tube of a diameter that admits two fingers. The finger is kept in this space, and depressed to hold back the rectum. The Spencer-Wells on the centre of the vaginal mucosa is now drawn to one side and a semilunar fold of connective tissue will be apparent on the opposite side. This fold is cut through close to the vaginal mucosa as far out as the tissue forceps on the carunculæ myrtiformes. The Spencer-Wells is drawn to the opposite side and a similar manœuvre performed.

The finger is now withdrawn, and the fingers of the left hand, which also holds the Spencer-Wells, are used to evert the posterior vaginal wall off which connective tissue is sponged with a swab. The redundant portion of the vaginal wall is cut away with scissors (Fig. 884), and care must be taken that only sufficient is removed to leave a parallel cylindrical tube after suture. At a point about an inch up, the vaginal wall will be found incorporated with a firm band of tissue —the levatores ani muscles— and especial care must be taken not to cut away too much vaginal mucosa here. Before severing the apex of this flap in the vaginal vault, it is advisable to insert the highest suture as, if the vaginal flap is cut off, it may be difficult to find the central point. The cut edges of the vaginal mucosa are then united from above downwards with a continuous catgut suture (Fig. 885) and, if the dissection has been accurately planned, there is no dead space. As the suturing proceeds, a point is reached where the levatores ani blend with the vaginal wall, and the strong ridge of their edges is apparent. The end of this continuous suture should now be drawn firmly upwards by the assistant. This manœuvre will throw the levator ani into still more prominent relief. Two or three interrupted

Fig. 885.—Inserting first suture before completely removing posterior vaginal flap.

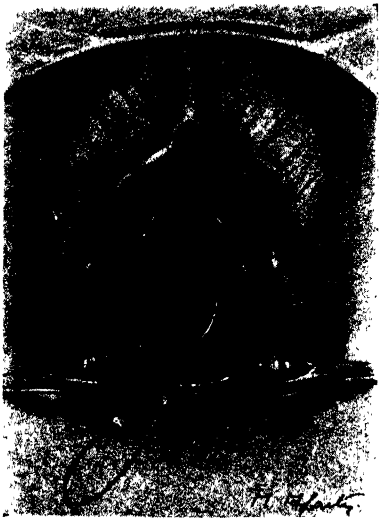

Fig. 886.—Vaginal flap partly sutured : needle picking up levator ani muscles.

sutures should be put into the levatores ani muscles, uniting the edges of the two muscles together (Fig. 886).

The vaginal suture is then continued to the tissue forceps on the carunculæ myrtiformes. When these forceps are reached they are removed, and again the long end of the continuous suture is pulled firmly upwards by the assistant. The cut edges of the skin of the perineum may require trimming to obtain two even edges. Immediately deep to these cut edges will be found the fascia covering the muscles of the superficial perineal group, and these muscles should be united by two or three interrupted sutures, similar to those in the levatores ani muscles. The continuous suture is continued to unite the skin of the perineum.

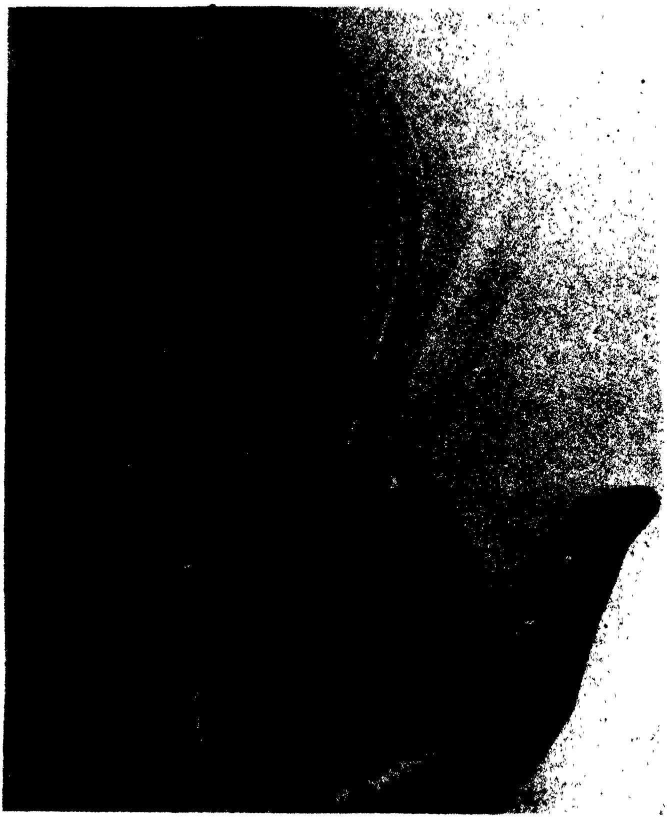

Fig. 887.—Demonstrating recto-vaginal fistula.

2. **For complete tear and recto-vaginal fistula.**—The same technique is carried out for both these conditions. In a recto-vaginal fistula, the full operation is the only one likely to be successful. Attempts to pare the edges and suture the hole invariably end in failure.

The operation begins in much the same way as that for repair of rectocele (Fig. 887). The labia are separated (Fig. 888), the carunculæ myrtiformes defined, and the last one on each side picked up with tissue forceps, which are held apart. The ridge thrown up in this case consists of vaginal mucosa united to rectal mucosa, and it is cut off as described above. (Fig. 889.) The posterior vaginal wall is dissected up again, but usually only for a very short distance, as in most cases of complete tear there is no redundance. Having dissected and trimmed the posterior vaginal flap, attention is next paid to the rectum and anal canal. Examination of the skin of the rectal margin will show that the rugæ, instead of being arranged in a circle round the anal orifice, are arranged as a fan posteriorly only, and at each edge of the fan a dimple will be seen, which represents the end of the torn retracted external sphincter. This point is seized with dissecting forceps and drawn upwards and to the opposite side, and a cut is made with scissors outwards and downwards through the skin and subjacent tissue as far out as the anal rugæ extend. A similar manœuvre is carried out on the opposite side. The anal canal is freed from the levator ani muscles by gentle dissection with a swab, assisted if necessary

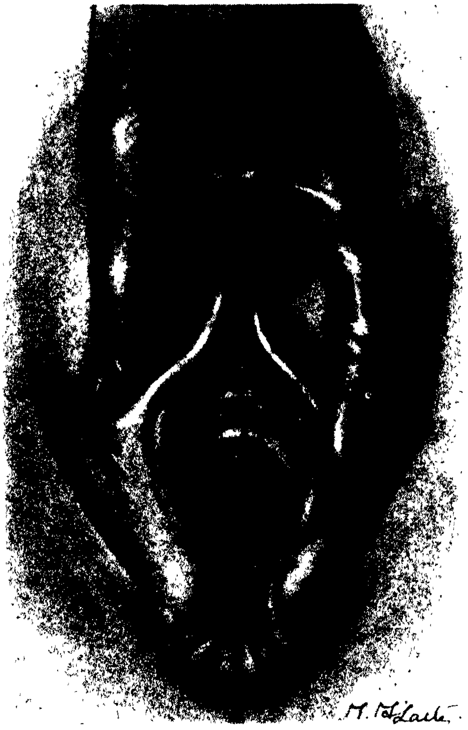

Fig. 888.—Demonstrating complete tear of perineum.

Fig. 889.—Removing scar tissue between vagina and anus.

by a few snips with scissors (Fig. 890). A continuous suture is inserted into the submucous coat of the anal canal, carefully avoiding the lumen, starting at the apex and continuing to the junction of mucosa and skin. A second suture, of the Lembert type, is put into the internal anal sphincter: this should completely cover the first suture line. A couple of interrupted sutures are next inserted to join the torn ends of the external sphincter. Sometimes this muscle is not apparent, but it can always be found by inserting a suture fairly deeply in the apex of the posterolateral cuts that were made to free the anus (Fig. 891). When these are tied, they should cause the fanlike arrangement of rugæ to become almost circular around the anal orifice.

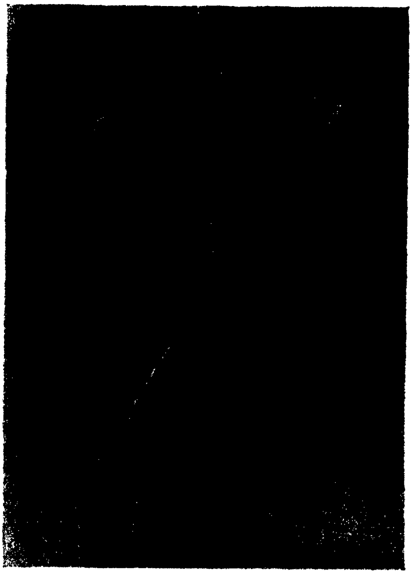

Fig. 890.—Dissecting up posterior vaginal flap.

Fig. 891.—The needle shows the suture in the rectal muscle tissue : the Reverdin needle is shown picking up the external sphincter ani.

The operation is completed by suturing the vaginal mucosa, levatores ani muscles and superficial perineal muscles in exactly the same manner as in perineorrhaphy for rectocele (*vide supra*), except that the continuous suture in the posterior vaginal wall should not be continued on to the skin of the perineum (Fig. 892). The edges of the skin of the perineum should be united by a series of interrupted sutures (Fig. 893), as it is likely that this area is infected with bowel organisms and, if a continuous suture becomes infected, it will give way throughout its length, whereas one interrupted suture only giving way will not cause much delay in healing.

Fig. 892.—Levator ani suture : suturing posterior vaginal wall.

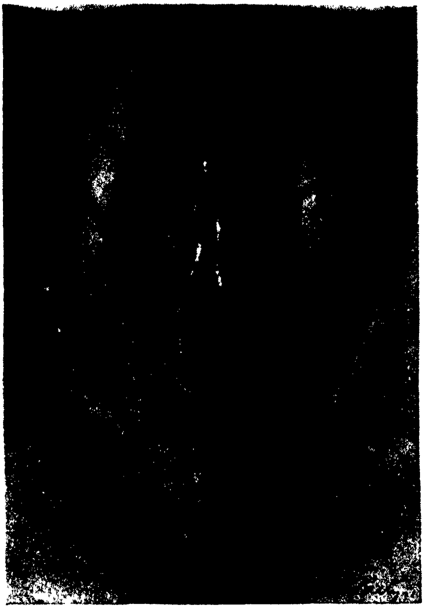

Fig. 893.—Repair complete.

IV. OPERATIONS ON THE CERVIX

DILATATION OF THE CERVIX AND CURETTAGE OF THE UTERUS

Perhaps the commonest and certainly the simplest operation on the cervix is dilatation. This operation is sometimes an aid to diagnosis and at other times a means of treatment. In both cases the technique is the same.

After routine surgical cleansing of the vulva and vagina, a speculum such as an Auvard's self-retaining speculum, is placed in the vagina. The cervix is steadied by volsellum forceps (Fig. 894), and the uterine sound is passed through the cervix, to determine the length and direction of the uterine cavity. The angle at which it passes is carefully noted, and graduated dilators are passed one after the other in the same direction and for the same distance until the requisite dilatation is attained. Further procedures as indicated can now be undertaken.

The endometrium can be removed with a curette, either as a routine when the operation is done for sterility, or to obtain specimens for microscopic section for diagnosis. A sharp curette is passed through the cervix to the fundus and, with a series of strokes from fundus to cervix, an endeavour is made to remove the entire endometrium.

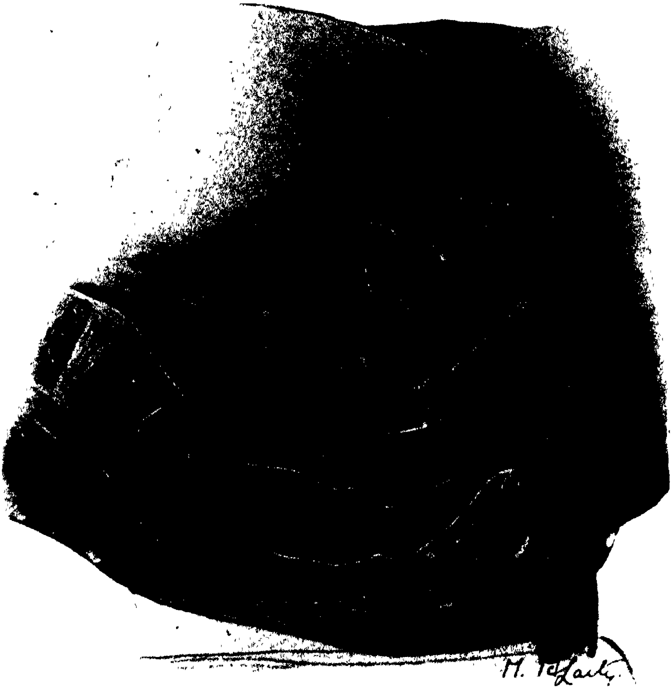

Fig. 894.—Sagittal section of the pelvic organs.

After curetting for any cause, it is often advisable to swab the uterine cavity with an antiseptic such as Tinct. iodi. mitis, violet green solution, or spirit, or with a caustic solution such as iodized phenol. The solution may be applied on wool wrapped round a Playfair's probe or on a small gauze swab introduced by dressing forceps.

Insufflation of the Fallopian Tubes

To determine the patency of the Fallopian tubes, after dilating the cervix, the last graduated dilator passed is hollow and is connected up either to a rubber bulb containing air, or to a small cylinder of carbon-dioxide gas. The whole system is connected to a manometer and the gas (or air) allowed to pass through the dilator into the cavity of the uterus. If the tubes are normally patent, the gas (or air) passes through at a pressure of about 100 mm. Hg. In some cases no gas (or air) passes until a pressure of over 200 mm.Hg. is reached : if so, this pressure should be sustained for about a minute. If still no gas passes, the tubes are usually blocked, but in some cases, after an interval, the pressure drops, and gas thereafter continues to pass through the tubes at a much lower pressure. The probable explanation is either that kinks in the tubes have been straightened out or that light, filmy adhesions of the abdominal ostium have been broken down, so that the tubes, previously partially blocked, have been made patent. At the conclusion of this operation, it is usual to curette, in order to remove the endometrium which has been damaged by the pressure.

MYOMECTOMY

Small submucous fibroids can sometimes be enucleated after fully dilating the cervix. A fibroid which can be felt by the finger inserted through the dilated cervix is seized by volsellum or ovum forceps and twisted out of its bed. The twisting will occlude the blood vessels and stop all bleeding. Larger fibroids may be removed in favourable circumstances by morcellement. The cervix should be dilated to the extent of the largest dilator, the nearest part of the fibroid is seized with volsellum forceps and, with a pair of scissors, as much of the fibroid as can be reached is cut off. The manœuvre is repeated until all the fibroid has been removed.

A definite risk of this operation is due to the partial inversion of the uterus, so that, towards the end of the morcellement, the uterus may have been cut right through and the peritoneal cavity opened. As these fibroids are frequently septic, this is a serious complication. It should be dealt with expectantly, the hole in the uterus being repaired immediately with one or two catgut sutures, and the patient nursed in the Fowler position in the hope that there may be no more than local peritonitis.

TRACHELORRHAPHY

Deep tears of the cervix are sometimes best treated by a plastic operation. The cervix must be exposed as above, with Auvard's speculum, grasped and steadied by volsellum forceps. It is then drawn to the opposite side, to bring the laceration as much into view as possible. A V-shaped incision is made with a scalpel on the vaginal portion, just clearing the edges of the laceration and taking especial care that the apex of the V well clears the apex of the laceration. This incision is carried deeply into the substance of the cervix, in order to expose the fibro-muscular portion clearly and definitely. An incision is now made on the endo-cervical aspect of each lip of the laceration deeply into the cervix to meet the first incision, to remove a V-shaped portion of tissue. Starting at the apex, sutures are then inserted. They must be taken fairly widely—i.e. about one quarter of an inch from the cut edge—on the vaginal surface and must pass deeply through the tissue of the cervix, to emerge just under the cervical mucosa. The needle is then passed through the other side, in exactly the reverse direction, so as to emerge on the vaginal portion one quarter of an inch from the cut edge. A series of sutures is passed. The one at the apex is tied first, and the others in order downwards. The operation is thus completed and the cervix restored to its normal appearance.

AMPUTATION OF THE CERVIX

This operation is best done by the method originally described by Victor Bonney—often known as Sturmdorf's operation. The cervix is exposed by inserting Auvard's speculum as above, and seized and steadied by volsellum forceps. It may be advisable to dilate the cervix to a small extent. A horseshoe-shaped flap, with the convexity downwards, is marked out with a scalpel on the anterior surface of the cervix and the mucous membrane is dissected up until as much of the cervix as it is proposed to remove is exposed. A similar flap is then marked out and dissected up on the posterior wall of the cervix (Fig. 895). The descending cervical branches of the uterine artery will be lying in the connective tissue on each side at the angles where these two flaps meet. These vessels should be ligated, by passing a suture deep to them at either side and tying superficially to the connective tissue containing the vessels, afterwards cutting the tissue and vessels below the tied sutures. The cervix is then cut across with a scalpel. As the anterior part is severed, it is as well to seize the stump with another volsellum forceps, as it is apt to retract and be difficult to secure again. Having seized it, the amputation is completed (Fig. 896).

Fig. 895.—Defining the flaps.

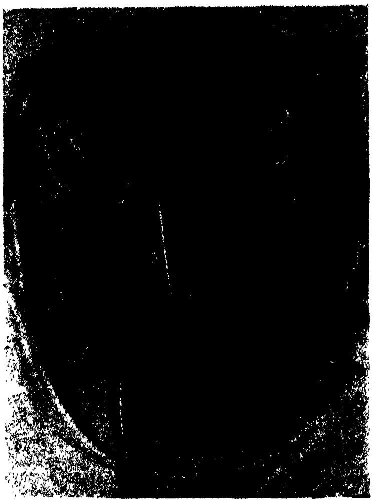

Fig 896.—After amputation of cervix.

The next stage of the operation is to suture the flaps over the stump.

The suture is passed through the edge of the anterior flap and loosely tied, leaving both ends long. Each end is then passed on a needle into the cervical canal, through the substance of the cervix, and out through the vaginal mucosa above the line of separation of the flap (Fig. 897). Each of these sutures should be so passed that it comes out about one quarter of an inch from the midline. When pulled tight and tied, it will be found to turn the flap into the lumen of the cervical canal and cover the anterior half of the stump. The posterior flap is dealt with similarly, and the sutures are used as tractors in place of the volsellum forceps. Two or more small sutures are necessary on either side to approximate the rest of the edges of the two flaps (Fig. 898).

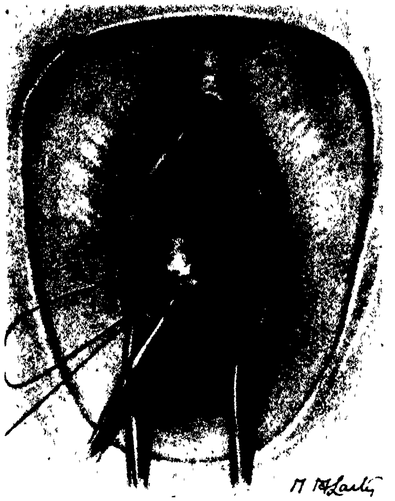

Fig. 897.—The suture turning anterior flap into the cervical canal.

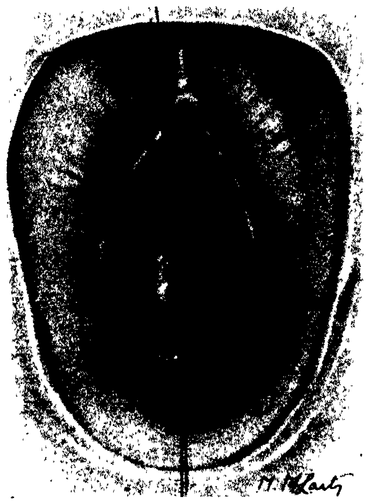

Fig. 898.—Appearance of cervix when amputation has been completed.

REMOVAL OF CERVICAL STUMP

It is sometimes necessary to remove the stump of the cervix which has been left at a previous sub-total hysterectomy. The patient is placed in the lithotomy position, and an Auvard's speculum inserted. The cervix is seized with volsellum forceps and drawn down as far as possible. A frenum of skin on the anterior surface of the stump is picked up by dissecting forceps, just as described in anterior colporrhaphy. This frenum is snipped by scissors and, by very careful blunt dissection, the stump is freed from the bladder. Great care must be taken, as the bladder is densely adherent to the stump and, if this viscus is injured, a vesico-vaginal fistula will result and will be very difficult to close. An assistant next holds the volsellum forceps towards the symphysis pubis, to expose to the operator's view the posterior aspect of the stump, and by a similar manœuvre the frenum of skin is picked up and incised and, by blunt dissection, the rectum and peritoneum of the pouch of Douglas are separated until the finger reaches the anterior dissection, and can be hooked right over the stump. The stump is then drawn to one side and the anterior incision in the vaginal mucosa joined by a lateral incision to the posterior incision, and the vaginal flap pushed upwards with a swab. A similar manœuvre is carried out on the opposite side. The first finger is then hooked right over the cervix, the cervix drawn to one side, and the tissue lateral to it, containing the cervical branches of the uterine artery, is seized with artery forceps and divided on the cervix side of the forceps. This manœuvre is repeated on the opposite side, and the cervix removed. If the peritoneal cavity has been opened, the peritoneum should be sutured to close the opening. The tissue in the artery forceps should be transfixed with a catgut ligature and tied. The cut edges of the vaginal flaps are then sutured with a continuous suture of catgut.

V. OPERATIONS ON THE UTERUS

HYSTERECTOMY

There are four main types of hysterectomy: sub-total, total, Wertheim's, and vaginal hysterectomy. *Sub-total hysterectomy* is suitable for nulliparous patients in whom there is no suspicion of a disease of the cervix, and a very clearly non-malignant condition, such as fibroids or metrcpathia hæmorrhagica, is the indication for removal. In all cases in which there is any suspicion of carcinoma

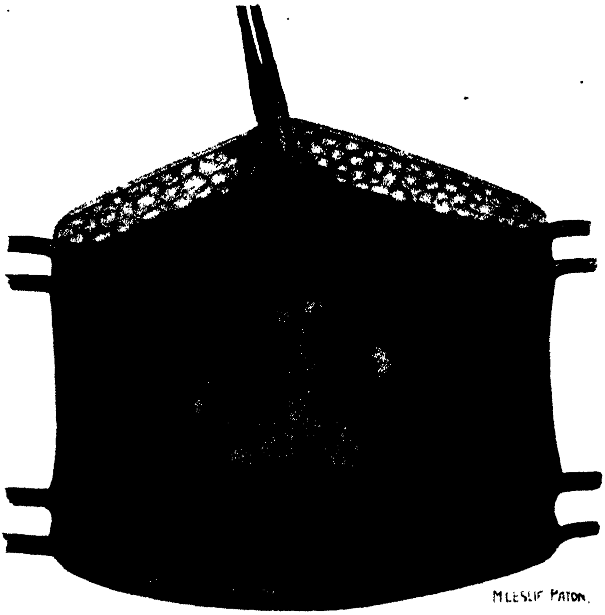

Fig. 899.—Laparotomy : uterus containing fibroids.

of the body, or in which there has been any trauma or infection of the cervix, *total hysterectomy* should be performed. *Wertheim's hysterectomy* is only performed for carcinoma of the cervix. *Vaginal hysterectomy* is particularly indicated for prolapse in a woman between forty and fifty who is also suffering from excessive loss at the periods, and the operation which will be described to illustrate this operation will be the combined vaginal hysterectomy and plastic repair of prolapse.

Abdominal hysterectomy.—In opening the abdomen, the incision of choice is a mid-line incision below the umbilicus. If, in the course of the incision, the muscle belly of both rectus abdominis muscles is exposed, there is very little risk of subsequent scar hernia, and the incision gives very much better access to the pelvis than any other.

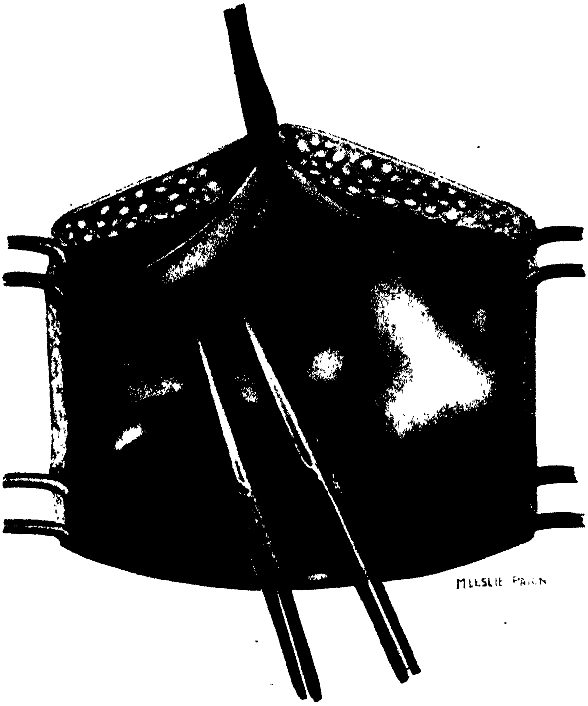

Fig. 900.—Clamping the left broad ligament.

Sub-total hysterectomy.—When this operation is being performed for fibroids, the incision should be just large enough to allow the operator to deliver the tumours (Fig. 899). The upper border of the broad ligament should be gently grasped between the thumb and first finger and the ovarian vessels, Fallopian tube and round ligaments defined and clamped with two pressure forceps, so that these structures can be divided without bleeding (Fig. 900). A similar manœuvre is then carried out on the opposite side. The uterus can then be lifted farther out of the wound and the reflection of peritoneum on to the upper surface of the bladder defined. If the forefinger is inserted between the layers of the broad ligament where it has been cut, it will enter a very loose connective tissue plane where the peritoneum is loosely attached to the front of the lower uterine segment just above the bladder (Fig. 901). The finger can easily be worked through this loose connective tissue plane to the opposite side, and the peritoneum is then cut from the uterus, using the finger to guard the bladder from injury. The bladder is pushed off the cervix just sufficiently to be clear of the point where the cervix is to be cut across. The forceps on the uterine cornua are used as tractors, and the uterus is drawn to one side and an artery forceps placed on the uterine artery just where it is ascending the cervix, slightly higher than the level of amputation. The vessels are cut with a scalpel and the manœuvre repeated on the opposite side. The cervix is cut straight across with a scalpel, completing the removal of the uterus.

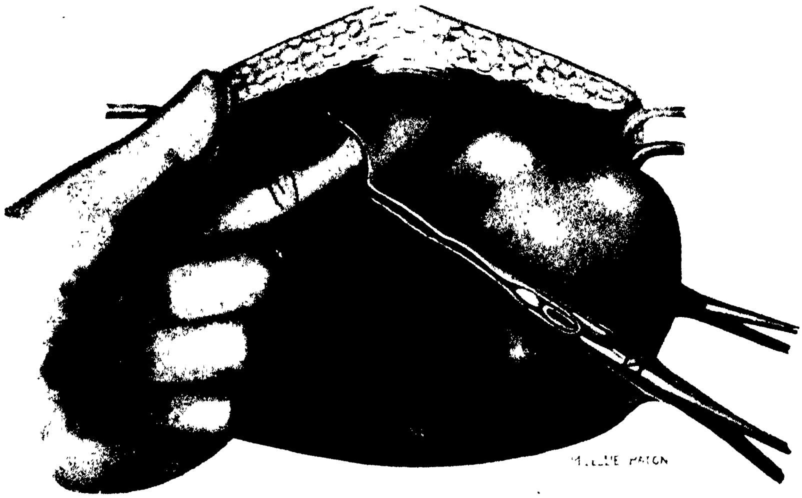

Fig. 901.—Separating the reflection of peritoneum on anterior surface of uterus.

The next step is to ligature the main vessels, and in each case it is advisable to ligature with a transfixion suture and a surrounding ligature. The forceps holding the left ovarian vessels should be taken first, and a needle passed between the round ligament and the ovarian vessels. It is tied round the ovarian vessels before the forceps is released and then the same ligature is used to surround the ovarian vessels and round ligament (Fig. 902). The left uterine vessels should next be dealt with, a needle being passed just through the edge of the cervix, immediately below the point of the forceps holding the uterine artery. A mass ligature is then tied, including all the tissues grasped by the forceps in the base of the broad ligament. As this ligature is tied, the forceps should be released and the uterine vessels seized again separately, and the ends of the ligature can then be used to make a second ligature around the vessels separately. These manœuvres are repeated for the right uterine and right ovarian pedicle respectively. In most cases, especially if care has been taken in inserting the needle for the ligature of the uterine arteries, the stump of the cervix will be quite dry, but occasionally there may be one or two bleeding points. The best way to control them is to put a Z- or cross-suture into the stump, which, when tied, will completely control any bleeding. To insert this suture, the needle should be a cutting pattern and should be passed through the substance of the anterior part of the stump from before backwards, and then through the posterior part of the stump, coming out through the peritoneal covering posterior to the cervix. The same needle is then passed similarly on the opposite side, and the two ends tied firmly. An additional advantage of this suture is that it rolls the raw surfaces of the stump inwards on to itself, as well as being hæmostatic.

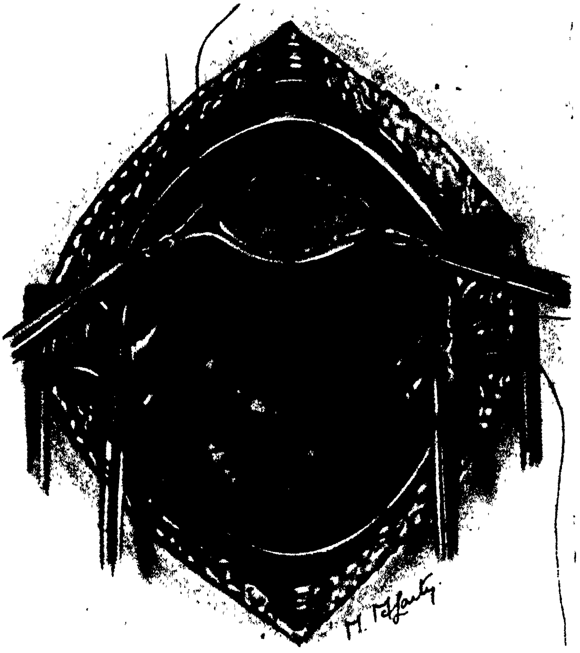

Fig. 902.—The pelvis after subtotal hysterectomy, showing the position of sutures in ovarian pedicle and round uterine artery.

The pelvic peritoneum may be closed in one of two ways, and the length and mobility of the ovarian pedicles indicate which method to use. If they are sufficiently long and mobile easily to reach the stump of the cervix, without tension, a purse-string suture round each half of the pelvic peritoneum will effectively bury all the raw ends of the pedicle and will, at the same time, fix the ovarian vessels and round ligaments on to the stump of the cervix, so affording a measure of support to the pelvic floor. To insert this suture, begin at the middle line of the anterior flap of peritoneum and, taking stitches at about half-inch intervals as near the free edge as is convenient, pass the suture outwards along the anterior flap, through the round ligaments and through the peritoneum covering the ovarian vessels, then through the edge of the peritoneum of the posterior flap of the broad ligament, the last stitch taking a good hold of the posterior lip of the stump of the cervix. Care must be taken to avoid puncturing the ovarian and uterine vessels. This suture is tied, leaving as much catgut as possible at the needle end, as it is also required to make a purse-string round the other half of the pelvic peritoneum in an exactly similar manner. The result of this suture is a very complete covering-in of all the raw area, and also the smallest possible intra-peritoneal scar, with correspondingly low risks of subsequent adhesions.

In some cases the ovarian pedicle is short, or insufficiently mobile to reach the cervix, especially if it has been necessary to remove the ovary. In this case the peritoneum should be repaired to cover any raw area on the pelvic floor with a continuous suture from side to side. Starting just mesial to the left ovarian pedicle, the suture is passed through the edge of the anterior layer of peritoneum, just through the edge of the ovarian pedicle, and then through the posterior peritoneal flap, and tied. The needle is then passed successively through the edges of the anterior and posterior flaps from left to right, and the right ovarian pedicle buried in a similar manner to the left.

The operation is completed by suturing the abdominal wall in layers.

Total hysterectomy.—The operation is commenced in an exactly similar manner to sub-total hysterectomy as far as separating the bladder, but in a total hysterectomy this dissection must be carried out farther down, until the bladder is well clear of the cervix and, moreover, it must be carried out laterally to clear the ureters from the anterior aspect of the broad ligament and cardinal ligaments. This dissection is best carried out by gently swabbing with gauze. If traction is applied to the forceps on the uterine cornua, it will be easy to determine when the cervix has been reached, as it can easily be felt through the anterior vaginal wall as soon as the bladder is clear of it. The uterine vessels should now be clearly visible at each lateral angle and, if the lateral angles have been swabbed clear to push away the ureters, the forceps can be placed on the uterine vessels so that the tip of the forceps actually takes up the vaginal angle itself. When the uterus is sufficiently mobile, it is sometimes a great advantage to include the uterosacral ligaments in the forceps taking the uterine vessels, as there is frequently a small vessel in the uterosacral ligament which may give rise to troublesome bleeding. In a similar way, a forceps is placed on the other uterine vessels, in both cases keeping as close to the cervix laterally as is possible. These vessels are divided with a scalpel and it will be found a great help to apply traction to the forceps on the uterine cornua while these vessels are being cut as, if this is done, the uterus will be drawn much nearer the surface and the area of cleared vagina will be more readily accessible for the next procedure. Having made sure that the bladder is clear of the vagina, a stab incision is made anteriorly in the vagina and carried outwards to either side. The vaginal portion of the cervix is seized with volsellum forceps and pulled upwards and forwards, while the scalpel cuts through the posterior vaginal fornix, and the uterus is removed. It is sometimes an advantage to place two or more forceps on the cut vaginal edge (Fig. 903), particularly if the forceps on the uterine vessels have not quite reached the vaginal angle, as in many cases there may be some bleeding from the vaginal edge and the assistant can, by pulling on the vaginal edge, make it easier to pass sutures.

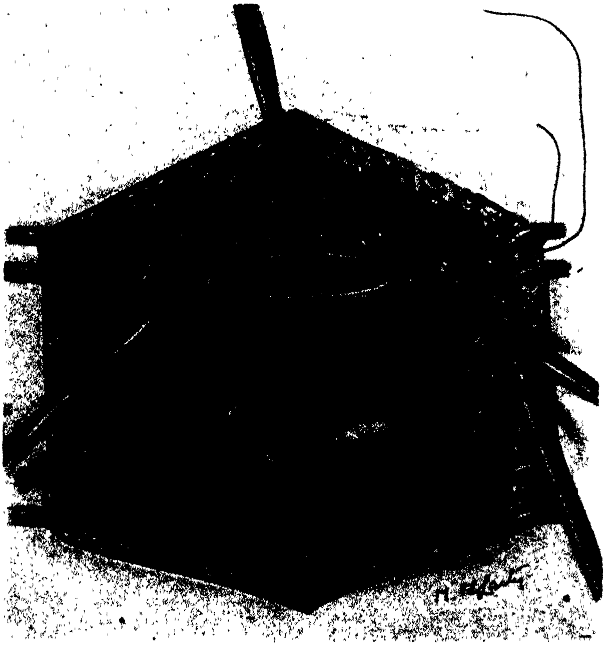

Fig. 903.—The pelvis after a total hysterectomy. The needle is shown transfixing the right ovarian pedicle : the open vagina is seen.

The ovarian vessels are ligatured precisely as described in the operation of sub-total hysterectomy. To ligature the uterine arteries, the suture on a needle should be passed through the vaginal angle, just below the point of the forceps, and should then be tied, surrounding the whole of the pedicle, the forceps being released as it is tied. The forceps should pick up the main vessels and, after securely tying the first ligature, the ends of the same ligature are used to encircle the uterine vessels as in sub-total hysterectomy. The cut vaginal edges should be sutured together with a continuous suture, starting well out on the angle and taking the whole thickness of the vaginal wall.

Some advocate leaving a portion of the vagina open for drainage, but if the main vessels have been properly secured, there will be nothing to drain, as a continuous suture will stop all oozing from the cut vagina and drainage is unnecessary. The peritoneum of the pelvic floor is dealt with in one of the two methods described in the operation for sub-total hysterectomy, and the abdomen closed.

Wertheim's hysterectomy.—This operation is one of the most formidable and severe operations in surgery, and certainly in gynæcological surgery, and for this reason the alternative method of treatment of carcinoma of the cervix by radium and X-rays has been studied and developed to its present high standard. Many cases of carcinoma of the cervix are best treated by irradiation, but in some, surgical extirpation of the growth is still indicated. Endocervical carcinoma does not respond well to radium. It also early gives rise to metastases in lymphatic glands, which are not easily accessible to rays, and even in a case that appears to be Group I, glands are likely to be involved. The general condition of the patient is another factor. In carefully selected cases, the results of the radical operation are better than the results of irradiation.

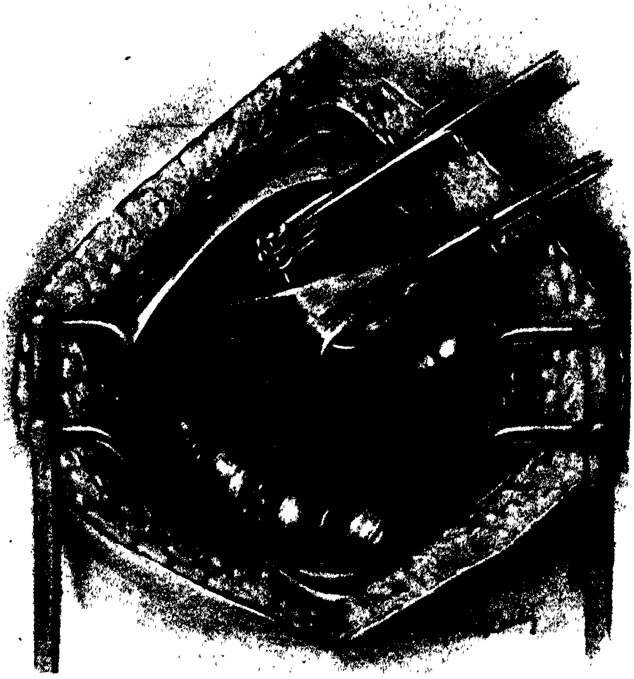

Fig. 904.—Ligating the left ovarian pedicle.

The patient must be catheterised immediately before the anæsthetic, as in this operation it is most important that the bladder should not only be empty, but should have contracted down to its smallest bulk and, if it happens to be fairly full when the patient is anæsthetised, the catheter may empty the bladder but leave it flabby and uncontracted. A spinal anæsthetic is useful as a nerve block, but it is not always satisfactory as an anæsthetic, as sometimes the effect of the spinal will begin to wear off before the long operation is completed. It is therefore better to start with a spinal, combined with a general anæsthetic. When the patient is anæsthetised, the vagina should be thoroughly cleansed and fairly firmly packed with gauze soaked in an antiseptic (2 per cent. formalin or violet green solution). The object of this pack is twofold: first of all, it helps to prevent the spill of cancer cells and organisms from the septic surface, and also, by distending the vagina, it makes it easier to define this structure in the course of the operation. The end of this gauze pack should be left long, and should be placed between the patient's legs, where it can be easily reached during the operation by an assistant, whose duty it will be to remove the pack during the course of the operation. After the abdomen has been opened, the round ligament, Fallopian tube and ovarian artery of the left side are seized in forceps placed across the top of the broad ligament about an inch from the uterine cornua. The uterus is drawn to the right side, thereby putting the round ligament and ovarian artery, where it crosses the brim of the pelvis,

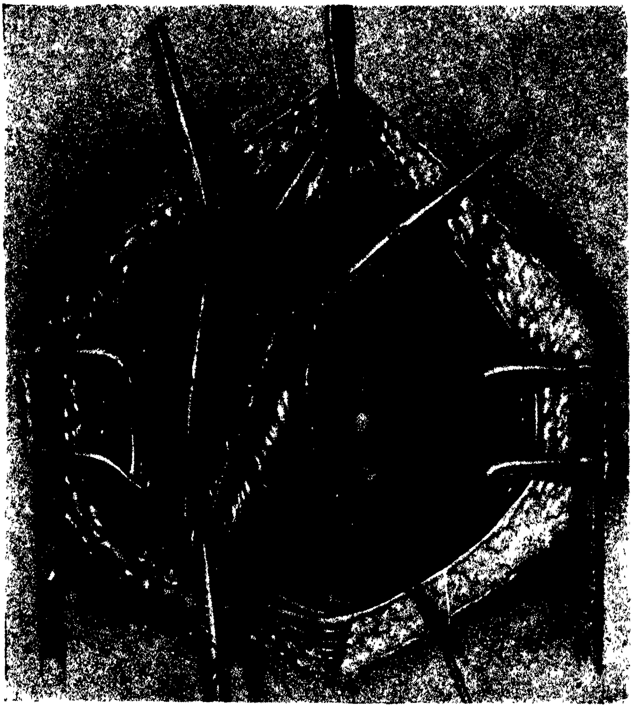

Fig. 905.—Defining the uterine artery and ureter.

on the stretch. The round ligament and ovarian vessels are encircled by a ligature on a needle, as far out laterally as possible, in order to remove as much of the cellular tissue of the broad ligaments as possible (Fig. 904). They are conveniently ligatured in continuity and then cut on the uterine side of the ligature, and the upper outer border of the broad ligament is divided at the same time (Fig. 905). The uterus is drawn still farther to the right and a ligature on a needle is passed deep to the utero-ovarian anastomosis, about half-way down the side of the body of the uterus. This ligature is tied, and is then used to encircle the top of the broad ligament and the forceps on the latter are removed. A strong ligature is advisable, and the ends should be seized in artery forceps, as this ligature is required as a tractor later in the operation. The same manœuvres are carried out on the right side, and the two tractor ligatures are held in the same forceps. Traction is put upon them, towards the patient's head, to draw the uterus as high out of the pelvis as it will come, in order to expose the peritoneum at the bladder reflection on the anterior surface of the lower uterine segment. The peritoneum is divided across the front of the uterus, joining up to the cut anterior layer of the broad ligament. It is then lifted towards the symphysis pubis, and the plane of cleavage between the bladder and cervix defined. The bladder is separated from the cervix by blunt dissection in the middle line, and then the separation is carefully extended laterally, taking great care not to injure the ureters, which may be closely adherent to the cervix, and even involved in malignant infiltration. If the bladder is actually involved it is advisable to abandon the operation.

The next stage is to define the ureters and uterine arteries. The uterus is drawn to the right by traction on the tractor ligatures, and held by an assistant. The ligatured ends of the round ligament and ovarian vessels are seized separately in artery forceps, and the peritoneum between them is divided about an inch towards the lateral pelvic wall, thus exposing the external iliac vessels. The peritoneum of the posterior layer of the broad ligament is seized in another pair of artery forceps and drawn gently towards the right. By blunt dissection with the fingers, the layers of the broad ligament are further separated, and the ureter is defined, closely applied to the posterior layer of peritoneum of the broad ligament, and is dissected out by blunt dissection. It is then traced forwards and downwards until it passes deep to the main uterine vessels which come off the anterior division of the internal iliac artery. By blunt dissection, the finger can be passed under the uterine vessels, and can be made completely to encircle them. The uterine vessels are then seized by two artery forceps and divided between the forceps. Each end is ligatured, as the uterine end will bleed if it is not, for there is a free anastomosis with the vaginal arteries. The uterine end of the uterine artery is again seized and drawn upwards, which manœuvre will further expose the ureter, which can be dissected out downwards and forwards until it disappears under a fairly strong band of connective tissue passing between the cervix and the angle of the bladder. This bridge of tissue contains branches of the superior vesical artery, and should be seized with artery forceps on the bladder side before it is divided. The ureter can now be traced forwards and inwards to the base of the bladder. The same manœuvre is carried out on the opposite side.

The uterus is now drawn forward towards the symphysis pubis and held there by an assistant. The peritoneum covering the posterior vaginal fornix is seized in forceps, and a definite line of demarcation will be found between the adherent peritoneum of the cervix and the loose peritoneum covering the vagina. A small incision is made in the peritoneum at about this point, sufficient to allow the finger to be inserted and, by blunt dissection with the finger, the peritoneum of the pouch of Douglas is separated from the vagina, and the incision widened to the full extent of the space between the utero-sacral ligaments. Two fingers can then be inserted and the blunt dissection carried down to separate rectum from vagina, as it is necessary to remove at least half, and preferably two-thirds of the vagina (Fig. 906).

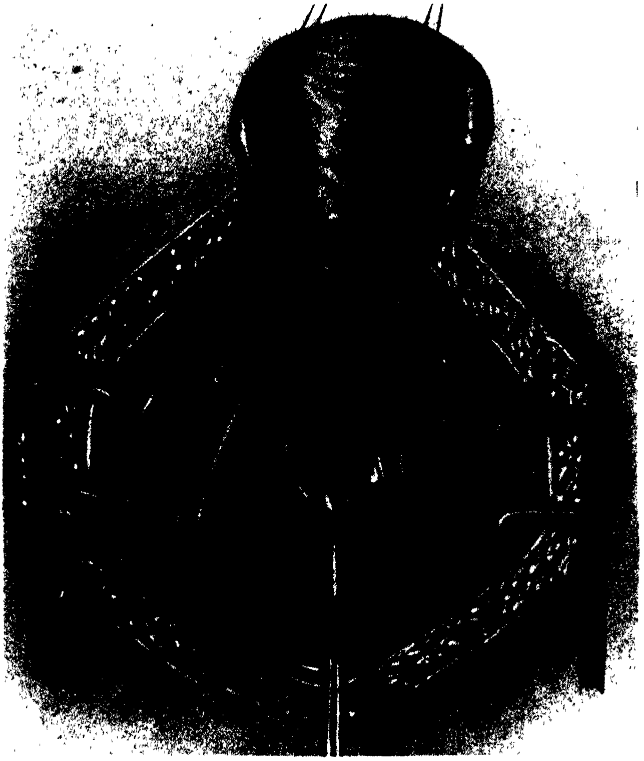

Fig. 906.—Dissection between rectum and vagina : the ureters are seen as well as the ligated main vessels.

The next manœuvre is to join the posterior peritoneal incision to the peritoneal incision in the posterior layer of the broad ligament. One finger should be placed between the ureter and the posterior layer of the broad ligament, and the other fingers in the dissection of the pouch of Douglas. The hand is then pressed backwards towards the sacrum, guarding the rectum and ureter, and then the peritoneum between the fingers is divided with scissors. There is sometimes quite a large vessel in the utero-sacral ligament which will require ligature. This manœuvre is repeated on the opposite side. The uterus is now retracted towards the patient's head and a further dissection of the bladder from the anterior vaginal wall is carried out, until a sufficient amount of vagina is exposed. The uterus will now be found to be held in the pelvis by the two lateral expansions of the cardinal ligaments, passing from the cervix and vault of the vagina below the ureter to the lateral pelvic wall. Where these ligaments join the pelvic wall, there is a plexus of veins which may give rise to troublesome bleeding, and it is best to secure the cardinal ligaments close to the pelvic wall with angular artery forceps before dividing them. They are eventually divided right up to the vagina, when the uterus and cervix will be found much more mobile, and coming farther out of the pelvis. An assistant removes the gauze pack from the vagina and the vaginal clamp is immediately applied, so that any cancer cells or septic material

Fig. 907.—Applying vaginal clamp.

in the vault of the vagina is shut in by the clamp (Fig. 907). Angular forceps should be placed below the clamp on each side of the vagina, as there is commonly a vessel in this situation. These forceps are also useful in defining the vagina later on. The vaginal clamp is now used as a tractor and the vagina is cautiously cut through with a scalpel as far down as possible, and the uterus and upper half or two-thirds of the vagina is removed (Fig. 908).

The next stage is to clear all cellular and glandular tissue from the external iliac vessels and the obturator fossa. The cellular tissue covering the external iliac artery is lifted up and incised and, by blunt dissection, the external iliac artery and vein are cleared. The vein is the more vulnerable, and care must be taken, especially if a gland is at all adherent to it. When the external iliac vein has been defined, blunt dissection can be carried out immediately below it in the obturator fossa and all the cellular and glandular tissue must be dissected out. The criterion of a good dissection is when the obturator nerve is cleanly exposed and isolated, crossing the obturator fossa. Any bleeding points must be secured. A transfixion ligature at each angle of the vagina secures the branches of the vaginal artery. If hæmostasis is good, the vagina can be closed by a continuous suture, but if there is oozing, it is advisable to leave a small pack of gauze soaked in flavine,

Fig. 908.—Dissecting glands from the iliac vessels.

the end of which is passed into the vagina, which is left open. The pack can be removed *via* the vulva twenty-four or forty-eight hours later. In suturing the peritoneum to complete the pelvic toilet, care must be taken not to injure the external iliac artery or a ureter : both of these structures may be very near the peritoneal edge.

The abdomen is closed and the patient is nursed for the first twelve hours in the Trendelenburg position. A continuous blood-drip transfusion is of great value in combating shock. The most important point in the after-care is the treatment of the bladder. This organ is always paralysed, and is unlikely to function normally for two or three weeks, and during this time it must not be allowed to become overdistended. The catheter should be passed at 4, 6, or 8-hourly intervals, according to the amount of urine excreted by the kidney. The bladder should not be allowed to contain more than 10 ozs. When the patient first voids urine spontaneously the bladder does not completely empty itself, and it is of supreme importance that a catheter be passed immediately to remove the residual urine.

Vaginal hysterectomy and plastic repair.—Some cases of prolapse, especially if accompanied by menorrhagia, without gross lesion of the uterus, are well treated by a combined vaginal hysterectomy and plastic repair. The operation is commenced much as in Fothergill's operation by seizing the cervix with volsellum forceps and pulling it down. The labia are separated either by retractors or by temporarily stitching them to the skin of the buttock, and the area of the anterior vaginal wall to be removed is defined. The bladder is separated from the cervix and by blunt dissection is pushed off the cervix and lower uterine segment, continuing upwards until the peritoneum is reached. The peritoneal cavity is then opened. A dissection is carried out on the posterior vaginal wall, exactly as described under perineorrhaphy and again this dissection is carried up until the peritoneum of the pouch of Douglas is opened. A point on either side of the vault of the anterior flap must be marked either by forceps or, better, by the insertion of a demarcation suture, the ends of which are left long and held in forceps. In a similar manner, two points must be marked on the posterior flap, and then the incision in the posterior flap is joined to the incision in the anterior vaginal wall. By blunt dissection, either with the finger or with a specially curved dissector, a passage is made through the broad ligament above the uterine artery which is clamped and divided. The finger is next passed into the peritoneal cavity through the anterior incision and the fundus of the uterus is hooked forwards and downwards and brought out into the vagina, when the tubes, round ligaments, and ovarian arteries can be clamped and divided. Sometimes, especially if the uterus is retroverted, it is easier to get the fundus out through the posterior incision. The remaining tissue between the uterine vessels and ovarian vessels is divided, taking care to secure any bleeding points before they retract. The divided ovarian pedicles are securely ligatured and then sutured together in the middle line. The suture, extending forwards, will close the anterior opening into the peritoneal cavity. The edges of the peritoneum of the pouch of Douglas are next sutured with a continuous suture, and the peritoneal cavity thus closed. The uterine vessels which have been secured in the mass of the cardinal ligaments are also ligatured and sutured together in the middle line. Good hæmostasis must be secured and then the anterior vaginal wall can be re-formed. Starting with the two demarcation ligatures, a continuous suture joins the two flaps, commencing at the vault and coming down the anterior wall. The flaps of the posterior wall are now dissected laterally as much as is necessary to form a cylindrical tube, the redundant part being cut away and, again commencing with the demarcation sutures in the posterior flaps, the posterior vaginal wall is re-formed. The levatores ani muscles and superficial perineal muscles are dealt with as in the operation for perineorrhaphy, and the operation is completed by suturing the skin of the perineum.

REMOVAL OF THE VAGINA

It is sometimes necessary for malignant disease or, more rarely, in simple conditions to perform a complete extirpation of the vagina. Whenever such procedure is necessary, it is obvious that the uterus must be removed also, and therefore the operation is a severe one. It is best carried out in three stages, commencing with the patient in the lithotomy position and freeing the lower two-thirds of the vagina, turning the patient to the Trendelenburg position and, from an abdominal incision removing the uterus and vagina, and completing the operation with the patient again in the lithotomy position.

The first stage of this operation, with the patient in the lithotomy position, is exactly similar to the operation for the cure of rectocele, and the finger dissection of the posterior vaginal wall is carried up as far as possible. The incision in the posterior fourchette is then carried round laterally. The anterior vaginal wall is stripped off the urethra and base of the bladder. An incision is made into the vaginal mucosa about an inch posterior to the urethral orifice, and the vaginal mucosa is stripped off the underlying tissues by blunt dissection. The dissection is in the same plane as described in the operation of anterior colporrhaphy, but in the reverse direction. These two dissections are extended laterally until they meet. At the lateral angles, branches from the internal pudic artery will require ligature, and gradually the lower two-thirds of the vagina is freed. The introitus is next closed with a purse-string suture, and this suture line further invaginated by a second purse-string suture. Bleeding points are seized and tied and the area lightly packed.

The second stage of the operation, with the patient in the Trendelenburg position.—The abdomen is opened and the operation proceeds as described for Wertheim's hysterectomy as far as dividing the broad ligaments and separating the vagina from the lower uterine segment, cervix and vault of vagina, when it will be found that the dissection meets that carried out from below. The uterus is now pulled forward, and held over the symphysis pubis, and the posterior dissection between the vagina and rectum is carried out again in the manner described in Wertheim's hysterectomy, until the lower dissection is again reached. The ureters must now be clearly defined, and the uterus and vagina will be found to be held only by the cardinal ligaments, which can be cut through close to the uterus, and the uterus and vagina removed *per* abdomen. The ovarian vessels and round ligaments are ligatured as described in the operation of hysterectomy. The cardinal ligaments and uterine arteries are sutured and ligatured as described in Wertheim's hysterectomy. The pelvic peritoneum is closed, completing the abdominal part of the operation, the abdomen closed, and the patient again put in the lithotomy position.

Third stage, in the lithotomy position.—The light pack is removed, and it will be found that the levatores ani muscles stand out clearly in view. Two or three interrupted sutures must be employed to bring them together, as described in the operation for rectocele. In a similar way, the superficial perineal muscles should be brought together, and finally the skin of the edges of the vulva sutured.

MYOMECTOMY

Fibroids may be removed by myomectomy. Pedunculated fibroids simply require cutting off and one or two sutures to stop bleeding from the pedicle. Intramural fibroids must be shelled out. Several fibroids may be removed in this way and sometimes several through the same primary uterine incision. In multiple myomectomy the important point is to get good hæmostasis. There is often free bleeding, and much loss of blood can be avoided by temporarily clamping the vessels before starting the operation. Light ring forceps are placed on the ovarian vessels on either side. The uterine vessels can be temporarily occluded by applying Bonney's myomectomy clamp. This instrument grips the cervix and compresses the uterine arteries between its jaws and the cervix.

An incision is made over the most prominent part of the fibroid and the incision should be carried well into the substance of the fibroid itself, when the muscle of the uterus and the capsule of the fibroid retract from the surface of the fibroid, giving a clear demarcation of the line of cleavage, through which it is easy by blunt dissection completely to enucleate the fibroid. The cavity from which the fibroid has been removed must be obliterated by a series of interrupted sutures which will, for the most part, give good hæmostasis. Only rarely is it necessary to ligature a bleeding vessel. When the top part of the cavity has been obliterated, redundant muscle and peritoneum may be cautiously trimmed and peritoneal coaptation secured by a continuous suture.

CÆSAREAN SECTION

(A) **Classical Cæsarean section.**—The classical operation is usually performed before the onset of labour or only just after labour has started and before rupture of the membranes. A midline incision is made in the abdominal wall from a point about 2 inches above to another point about 2 inches below the umbilicus, going just to the left of the umbilicus itself, and the abdominal cavity is opened (Fig. 909).

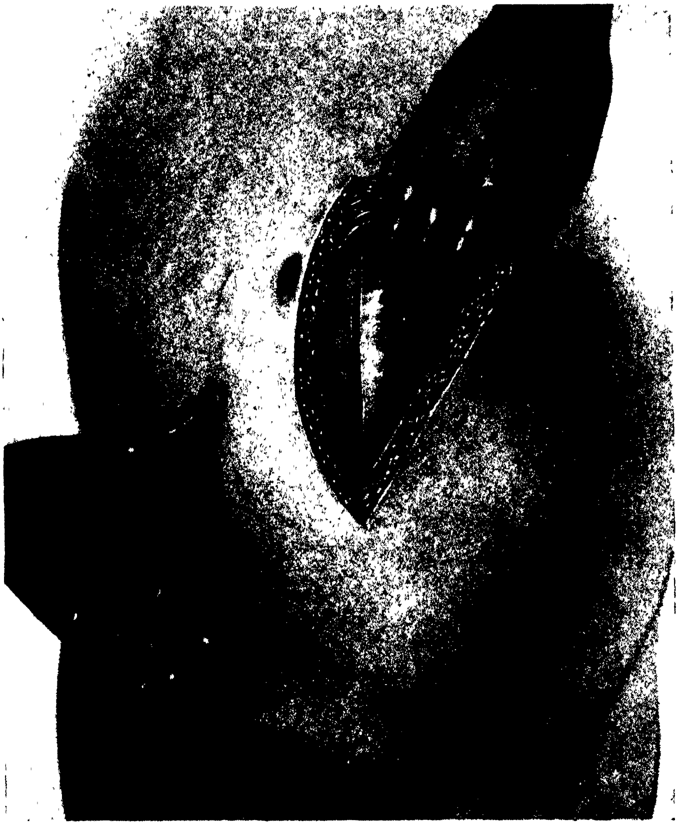

Fig. 909.—Incision for Classical Cæsarean section.

The uterus should next be centralised, as at term this organ is usually markedly on the right side of the abdomen. It can be easily centralised by the assistant placing his hand well to the right flank and pushing it towards the left. It is then incised by two or three sweeps of the knife. No attempt should be made to seize any bleeding points at this stage, as any such efforts will be quite fruitless. Care must be taken when the membranes are exposed, or the fœtus may be cut. When they are cut, the incision must be carefully carried through the whole thickness of the uterus throughout the length of the incision. The operator then inserts his hand into the uterus and identifies a leg and extracts it, breech first. Some difficulty may be experienced in freeing the arms. They can, however, be readily hooked out by the hand which is not holding the breech, and the child delivered.

The child should be held head downwards, to allow liquor and mucus to run out of its mouth and air passages, and should be kept head downwards until it is breathing well. The umbilical cord is clamped with two Spencer-Wells forceps and cut between them, and the child handed to an assistant. The finger is then placed in the upper angle of the uterine incision and the uterus delivered through the incision in the abdominal wall. It should then be wrapped in warm towels and compressed laterally, which will usually expel the placenta and control bleeding (Fig. 910). The membranes usually separate easily, and care must be taken to ascertain that they are complete, especially that the membranes lying in the lower uterine segment are removed.

Fig. 910.—Expressing the placenta.

In some cases, the placenta and membranes are unusually adherent, and it may be necessary to peel them off with a swab. When they have been removed, the uterus should be again compressed and wrapped up in warm towels to aid retraction and control bleeding. The incision in the uterus is closed in two layers and a non-absorbable suture such as silk is recommended. The first layer of sutures must take in muscle only, and care must be taken that the suture does not encroach on the endometrium as, if it does, an intra-uterine stitch sinus will inevitably result. Three or four such sutures are usually sufficient (Fig. 911).

Fig. 911.—The first layer of sutures.

The second layer of sutures starts from the peritoneal surface of the uterus, takes in at least half the thickness of the muscle of the uterus and, when it is tied, if the sutures have been accurately placed, will give good peritoneal apposition. Usually six or eight of these sutures will be necessary to secure good closure. Further peritonealisation can be secured by a Lembert's suture of fine catgut, covering the knots of the second layer of sutures (Fig. 912). The uterus is again compressed between towels, to secure retraction, and to express any accumulated blood clot. It is then returned to the abdomen and the abdominal wound closed.

(B) **Lower segment Cæsarean section.**—The lower segment operation is more suitable for patients who have been in labour for some hours : in fact, it is only after some hours' labour that the true lower segment develops. A midline incision about five inches long is made from a point an inch or two below the umbilicus to the upper border of the symphysis pubis. The abdomen is opened and the wound retracted to expose the uterus. The peritoneal reflection in the utero-vesical pouch is easily defined and the loose peritoneum in this area is incised transversely (Fig. 913). The uterine muscle is then cautiously cut through transversely. The incision should be curved, with the convexity downwards, as in this way there is less danger of injuring the uterine arteries and veins (Fig. 914). The incision is carried cautiously through the thickness of the uterus, until the fœtal scalp can be just seen through the membranes. The incision should now be

Fig. 912.—The first layer of sutures tied : second layer inserted.

Fig. 913.—Incising the loose peritoneum.

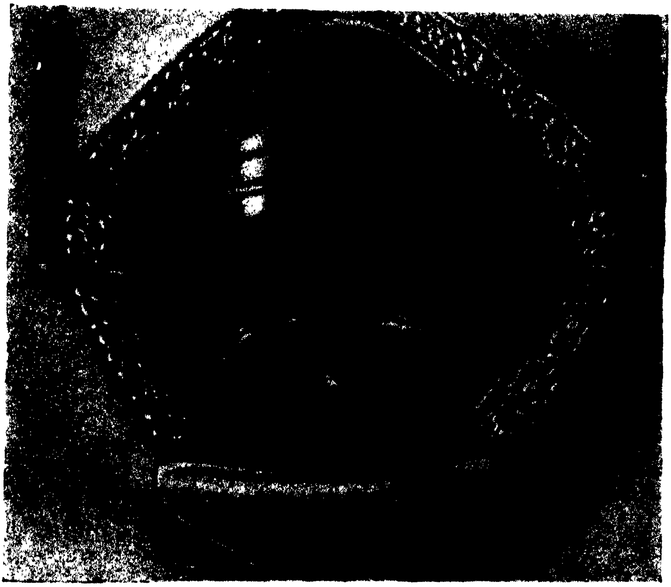

Fig. 914.—Dotted lines show position of curved incision in uterine muscle.

completed throughout its full width with scissors. The fœtal head can be levered through this incision, using one blade of the obstetric forceps as a vectis, or the fœtal scalp can be seized with Willett's scalp forceps and by gentle traction drawn up through the incision. Once the head has been delivered, the rest of the delivery is simple.

The child and cord are treated as described in the classical operation, but the placanta and membranes may be dealt with in one of two ways. If the case is a "suspect" case, the placental end of the cord should be cut off as close to the placenta as convenient, and left in the uterus. The uterine incision is closed with a catgut suture, and the placenta later expressed through the vagina. If the case is not "suspect," the placenta and membranes may be removed through the incision forthwith. The hand is inserted and the edge of the placenta felt for. The placenta is then peeled off the uterine wall and removed through the incision.

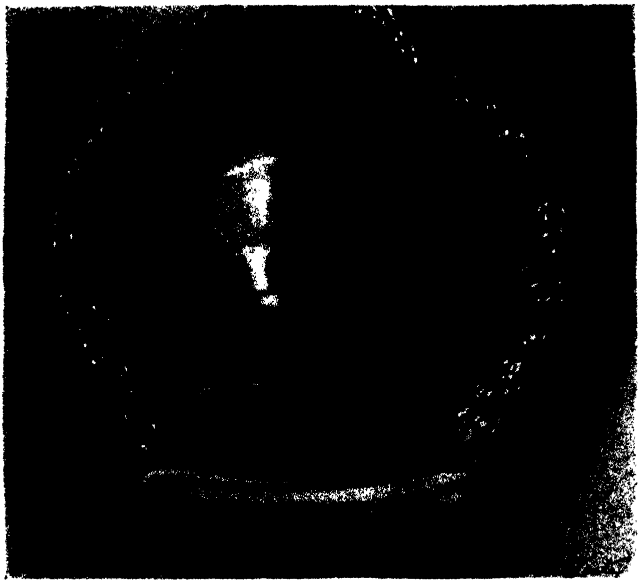

Fig. 915.—The uterine muscle is sutured : suturing the peritoneum.

The method of closing this incision differs considerably from that described for the classical operation. In the first place, the wall of the uterus is very thin, usually being less than a quarter of an inch thick. In the second place, this portion of the uterus is not contracting and relaxing to the same extent during the puerperium ; and in the third place, very little autolysis is taking place. A catgut suture is preferable to a silk suture, and a continuous suture preferable to the interrupted sutures described in the classical operation (Fig. 915). A second catgut suture is used to close the incision in the loose peritoneum, and the abdomen is closed in the usual way.

ABDOMINAL HYSTEROTOMY

Abdominal hysterotomy for termination of an early pregnancy is usually combined with sterilisation. It may be done by performing a miniature classical Cæsarean section, followed by an operation on the Fallopian tubes as described on page 1880). A more satisfactory way, however, is to amputate the fundus of the uterus, including the uterine portions of both Fallopian tubes. To carry out this procedure, the abdomen is opened by a sub-umbilical incision and the body of the uterus delivered through the wound. A forceps is placed so as to grasp the Fallopian tube, round ligament, and the blood vessels in the broad ligament about half an inch from the point where the Fallopian tube meets the uterus. A forceps is placed in a similar position on the opposite side. An incision is now made transversely right across the front of the uterus, just above the level of the forceps. The tubes, round ligaments and vessels are severed on either side and the incision carried down through the wall of the uterus until the decidua is reached (Fig. 916). A second incision is then made on the posterior wall of the uterus at the same level, joining the cut edges of the broad ligaments and also carried down to the decidua. With the forefinger, the membranes can easily be separated from the body and lower segment of the uterus, and the embryo removed intact, attached to the fundus. If the two lateral forceps have been well placed, there will be very little bleeding.

Fig. 916.—Incising the uterus for fundectomy.

A suture should now be passed just internal to the point of one of the forceps and tied around the vessels, round ligament and Fallopian tube just below the forceps. The forceps should be removed as this ligature is tied and re-applied after tying so that it can be used as a tractor. The tissues enclosed in the other forceps are treated in the same way and the other forceps re-applied (Fig. 917).

The incision into the uterus is closed as described for the classical operation, except that the first suture should be placed in the middle of the incision, and subsequent sutures on alternate sides, as the anterior and posterior walls of the uterus are not the same width and, if the sutures are commenced at one end, it will be difficult to close the other end neatly. The last suture at either end should be so placed that the end of the stump of the Fallopian tube and vessels is buried under the peritoneum. The operation is completed by closing the abdominal wall in the usual way.

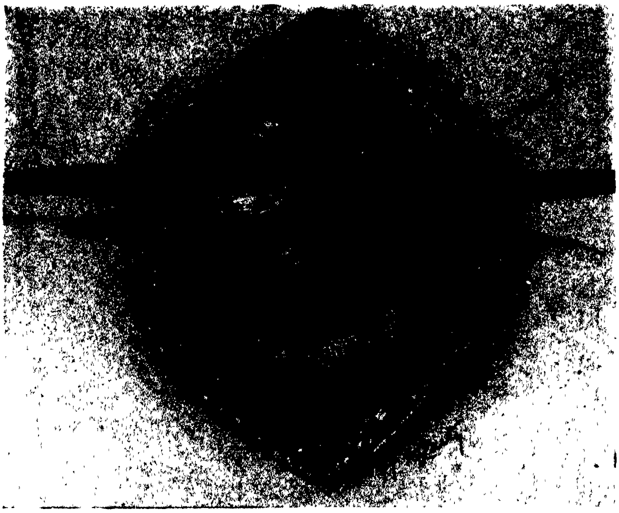

Fig. 917.—Method of suturing after fundectomy.

SHORTENING THE ROUND LIGAMENTS: MODIFIED GILLIAM'S OPERATION

Some cases of retroversion and retroflexion of the uterus are well treated by an operation for pleating and fixing the round ligaments. After opening the abdomen in the middle line, the left round ligament is picked up fairly close to the lateral pelvic wall and a running suture is passed through it four or five times, right up to the uterine cornua. When this suture is tied, the ligament will be pleated. A non-absorbable silk or thread ligature is preferable and the ends are left about eight inches long, and a similar manœuvre carried out on the right side. A pair of curved forceps (round ligament forceps) is passed deep to the fascial sheath of the rectus abdominis muscle and superficial to the belly of the muscle, to the internal abdominal ring. The point of the forceps is then manœuvred through the abdominal ring and between the layers of the peritoneum of the broad ligament. A small incision is made in the peritoneum, close to the pleated round ligament, and the point of the forceps is manœuvred through this opening. The ends of the ligature are seized by the forceps and the forceps withdrawn, thus telescoping the pleated round ligament into the broad ligament through the internal abdominal ring and under the sheath of the rectus. This manœuvre is repeated on the opposite side. The ends of these ligatures are then threaded on needles, and the skin and subcutaneous fat dissected from the anterior surface of the rectus sheath about an inch and a half laterally on each side ; the needles carrying the sutures are passed from below upwards, through the sheath of the rectus, and tied on the anterior surface, thus fixing the pleated round ligament to the anterior abdominal wall.

VENTRAL FIXATION OF THE UTERUS

A more firm fixing of the uterus, suitable for some cases of prolapse, can be performed by passing three silk sutures deeply through the substance of the muscle of the anterior wall of the uterus. The highest of these sutures should be close to the fundus. the lowest just above the peritoneal reflection over the bladder and the centre one about midway between. Each end of these sutures is then passed from within outwards, through the peritoneum, rectus muscle, and rectus sheath. When they are tied across the middle line, the uterus is firmly anchored to the anterior abdominal wall.

VI. OPERATIONS ON THE OVARIES

OVARIOTOMY

The abdomen should be opened by a midline incision. Ovarian cysts are sometimes of great size and for large ones it is particularly important to make a midline incision as, in order to deliver the cyst, the incision may have to extend from the ensiform cartilage to the symphysis pubis. Moreover, with a large cyst it is not possible to determine from which ovary it has arisen, and the pedicle may be very short and almost inaccessible through a paramedian incision on the wrong side. Further, it is not possible to distinguish a parovarian or broad ligament cyst from an ovarian cyst, and a broad ligament cyst may be inaccessible through any but a median incision.

It is a general practice to endeavour to remove an ovarian cyst unruptured as, however innocent a tumour may appear externally, there is always the possibility that parts of it are highly malignant, and the spill of fragments of carcinoma in the peritoneal cavity may result in metastases. With modern mechanical suction apparatus it is at times permissible to reduce the size of a very large cyst. The cyst should be delivered through the wound and its pedicle clamped with one, two, or more pressure forceps, and the cyst removed (Figs. 918 and 919). The pedicle is then transfixed and ligatured with as many transfixion ligatures as may be necessary to secure hæmostasis. If the pedicle is very broad, care must be taken to ensure that the ureter is not looped up in the pedicle. Sometimes adhesions are found. Usually they are easily separated, but they may require clamping and cutting and subsequent ligature. Any bleeding points must be secured and ligatured.

Broad ligament cysts must be shelled out. The peritoneum covering the cyst should be carefully incised and by digital dissection the cyst can be completely separated from its bed, provided sufficient care is used to avoid rupture. Bleeding points in the wall of the bed must be carefully secured and ligatured. The peritoneum is sutured to cover the raw area. If good hæmostasis has been secured, no other treatment is required, as the intra-abdominal pressure will cause the space to collapse. If hæmostasis is not satisfactory, the space should be temporarily drained through a stab wound well to the side of the anterior abdominal wall. Should the cyst be inadvertently ruptured it may be impossible to remove the whole of it, and as much as possible should be trimmed away and the rest marsupialized by suturing the peritoneum to the cut edge of the remains of the cyst.

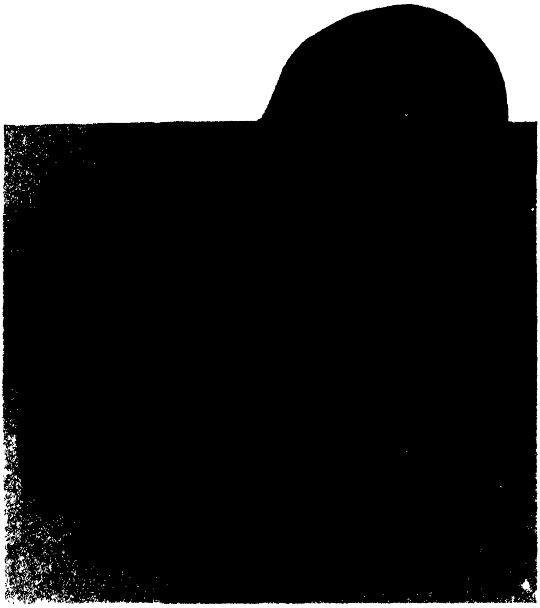

Fig. 918.—Clamping the pedicle of an ovarian cyst.

SALPINGECTOMY

The removal of the whole or part of the Fallopian tube for pyosalpinx or ectopic gestation is a simple operation. There may be some adhesions to separate by gentle manipulation with the fingers, perhaps aided by a swab. More dense adhesions may be best divided with scissors. When the tube is freed, the mesosalpinx is clamped with one forceps, and another is placed on the junction of the tube to the uterine cornua. The tube is then cut off with either scissors or a scalpel, and the tissues enclosed in the forceps ligatured with a simple transfixion ligature.

SALPINGO-OÖPHORECTOMY

In some cases, the ovary is so completely involved that it is necessary to remove it as well as the tube. Adhesions are freed as above, the ovarian pedicle is seized with one pair of forceps, and another pair is put on the tubo-ovarian ligament and upper edge of the broad ligament, close to the uterine cornua. If care is taken to see that this forceps includes the utero-ovarian anastomosis and the ligament of the ovary, there will be no bleeding when the tube and ovary are removed, and the tissues may be tied off with ligatures as above. It may sometimes happen that a vessel in the ovarian pedicle slips out of the ligature and retracts, in which case a hæmatoma will form between the layers of peritoneum. In such a case, the simplest procedure is to pick up the ovarian vessels half an inch above the upper limit of the hæmatoma and pass an encircling ligature round them and tie the vessels in continuity.

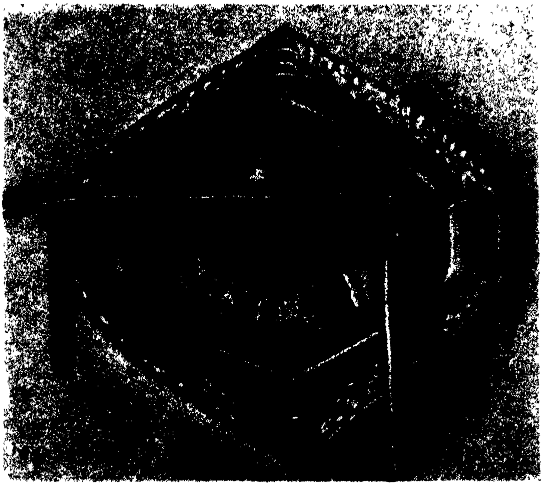

Fig. 919.—The pedicle after the cyst is removed.

SALPINGOSTOMY

Attempts to cure sterility due to blocks in the Fallopian tubes have so far only met with moderate success, and each case must be dealt with on its merits. Should the Fallopian tubes be blocked only at the fimbrial end, it appears comparatively easy to perform salpingostomy. The operation is simple. The tube is slit up for about an inch and, with fine catgut, the peritoneal coat is sutured to the mucosa.

Frequently, however, the tube is blocked at the uterine end. If there be two or three inches of patent tube, the patent portion can be isolated and implanted, so that one end is in the uterine cavity. The tube is divided, and any small bleeding points are seized and carefully ligatured with fine catgut, and two or three sutures are employed to anchor the peritoneal coat to the mucosa. The fundus of the uterus is now incised so that the incision goes to the lateral angle on the side of the tube to be employed. The proximal end of the tube is anchored in the uterine cavity by a fine catgut suture. One or two strands of thick catgut may be threaded through the lumen of the tube, the uterine ends of which are threaded through the eye of a silver probe. The probe is passed from the uterine cavity through the cervical canal into the vagina, so that the catgut can be withdrawn *per vaginam* a few days later. The uterine incision is then carefully sutured to get accurate apposition, good hæmostasis, and at the same time not unduly to compress the implanted portion of the tube.

VII. OPERATIONS FOR STERILIZATION

The simplest method is to occlude the Fallopian tube by passing a ligature round it and tying it tightly. Unfortunately this method is more likely to fail than to succeed. Section of the Fallopian tubes with ligature of the cut ends is also likely to fail. Section of the tube and ligation, so that the ends overlap, is more reliable, but has a rather high percentage of failures.

SALPINGECTOMY

This method is still more reliable. The mesosalpinx is clamped and divided, and the tube clamped close to the uterine cornua. The tube is then ligatured and the cut end buried by a purse-string suture and the cut vessels in the mesosalpinx ligatured.

CORNUECTOMY

A still more reliable method is to excise the interstitial portion of both tubes. This operation has been termed cornuectomy. A wedge-shaped portion of the uterine wall is excised on each side, taking care that in the incision the interstitial portion of the tube is included. The incision is then closed by interrupted sutures and the distal end of the tube ligatured.

FUNDECTOMY

A still more certain method is amputation of the fundus of the uterus. Pressure forceps are applied on either side of the uterus about an inch below the insertion of the Fallopian tubes. Included in these forceps are the Fallopian tube, the round ligament, the ligament of the ovary and the utero-ovarian vessels. The fundus of the uterus including the interstitial portion of the Fallopian tubes is then amputated

(Fig. 916, p. 1875). A ligature is next passed through the wall of the uterus just below the point of the pressure forceps and tied below it, including all the structures within its grasp. The top of the stump of the uterus is then sutured, as though it were a transverse Cæsarean section scar, by a series of interrupted sutures (Fig. 917, p. 1876). Accurate peritonealization is secured by a continuous suture from one end of the incision to the other.

SALPINGOCLEISIS

It is sometimes expedient temporarily to sterilize a woman, and the fimbriated ends of the Fallopian tube can be buried between the layers of the broad ligament in such a way that at a future date they can be liberated. The first step is to divide the ovarian fimbria and about an inch of the mesosalpinx at the fimbriated end of the tube. The cut portion of the mesosalpinx attached to the tube is ligatured and the ends of the ligature left long. A small incision is made into the peritoneum between the tube and the round ligaments and, with a finger or blunt dissector, the layers of the broad ligament are separated. The long ends of the ligature are then threaded on needles, and each needle is passed to the lowest point of the dissection and the threads brought out through the anterior layer of the broad ligament, so that when they are pulled and tied, the fimbriated end of the Fallopian tube is buried between layers of the broad ligament. A few fine sutures are employed completely to close the incision in the peritoneum and to anchor the Fallopian tube still more securely. The abdomen is closed in the usual way.

VIII. PRESACRAL SYMPATHECTOMY

This operation aims at removing the whole of the presacral plexus of nerves, which consists usually of several trunks joining the abdominal sympathetic system with the hypogastric plexus. The abdomen is opened in the midline, just below the umbilicus. The intestines are packed off so that the bifurcation of the aorta into the two common iliac arteries is defined. The peritoneum over this area is incised and the cellular tissue containing the nerve trunks is carefully dissected off the common iliac vessels (Fig. 920). It is an operation which needs considerable care, as frequently the ureter or the superior hæmorrhoidal vessels are embedded in the cellular tissue and fat, and may not be easily identified. When the cellular tissue containing the nerve trunks has been freed, about one inch to one and a half inches is removed between forceps, and the mass above and below the removed area is ligated, as there are small vessels which would otherwise bleed. The incision in the peritoneum is then closed and the operation completed by closing the abdominal incision.

IX. ACCIDENTS DURING OPERATIONS

During the course of gynæcological operations neighbouring structures are sometimes accidentally damaged, particularly the rectum, bowel, bladder and ureters. Damage to these structures may have very serious results, not only in immediate complications, but also from fistulæ which may be exceedingly difficult to close.

Rectum.—The rectum is very rarely damaged in perineorrhaphy: even if it is, it is unusual for the result to be serious if it is noticed at the time and sutured. If it is not noticed, it is likely there will be an infection of the operation area which may result in a good deal of suppuration, but is unlikely to give rise to a permanent fistula. If there is suppuration, the ultimate result will not be as satisfactory as if healing is by first intention, but is quite likely to end with a surprisingly good result. The rectum may also be injured in abdominal operations. Inflammatory and malignant masses may be adherent, and attempts at removal may open the rectum. It is obvious in such a case that there is a considerable risk of infecting the peritoneal cavity and giving rise to general peritonitis, but if the rent is observed and carefully sutured there is a good chance that no ill effects whatsoever will follow.

Fig. 920.—Presacral sympathectomy.

The bowel, either large or small, may accidentally be cut on opening the abdomen, particularly if there are adhesions to the anterior abdominal wall. Such an injury again carries a grave risk of producing peritonitis. (For details of suture of intestine, see section on Enterectomy and Intestinal Anastomosis, Vol. I, p. 908.)

Bladder.—The bladder may be accidentally cut during anterior colporrhaphy. If sutured at the time, it usually heals well, but sometimes—probably due to infection—the suture line breaks down and a vesico-vaginal fistula forms, which may be very troublesome indeed to close. The bladder is even more likely to be injured when an operation is undertaken through the vagina for the removal of the cervical stump of a sub-total hysterectomy, and may be even more difficult to close, as the injury is likely to be very near the ureteric orifices. In making an incision to open the abdomen, the bladder may be cut, particularly if it has not been efficiently emptied. Such an injury is not serious, provided it is recognized and sutured. It is usually extra-peritoneal, and it is very unlikely that a fistula will form. The bladder may also be injured during the manœuvre of separating this organ from the cervix uteri during the course of hysterectomy, particularly total hysterectomy and Wertheim's hysterectomy. In the latter it is always very serious, as the tissues are unhealthy, the bladder is devascularized and healing is poor. These same factors may produce a fistula by sloughing after operation. The fistula thus formed may only show itself a few days to six weeks after the operation. Fistulæ of this nature are always difficult to cure : they are frequently very small and multiple, and it may require two or three operations before a satisfactory result is obtained.

Ureters.—Ureters are very rarely injured at vaginal operations. They are very liable to injury during Wertheim's hysterectomy or during operations for broad ligament fibroids or parovarian cysts. Rarely, two or three inches of ureter may be drawn up into the pedicle of a simple ovarian cyst, and may be injured when the pedicle is cut through. If a ureter is cut, an effort must be made to implant it into the bladder. If it has been cut so high that it will not reach the bladder, the only course is to ligate it, in the hope that the kidney will atrophy and the remaining kidney carry on the excretory functions. For details of implantation of ureter, see Operations on the Kidney and Ureter, p. 1965.

MORTALITY

Mortality will vary according to the severity of the operation. Following all operations there are certain risks, which may be classified as follows :

A. Pneumonia and other lung complications.
B. Cardiac failure due either to valvular disease or to disease of the myocardium.
C. Pulmonary embolus.

D. Pyelitis and pyelonephrosis.
E. Sepsis, including septicæmia and peritonitis.
F. Hæmorrhage.
G. Surgical shock.
H. Unrecognized or incipient conditions such as diabetes, thyrotoxicosis and other complications that may be aggravated by the anæsthetic or the shock of the operation.

Vaginal operations should not have a mortality of more than about 0.5 per cent., the highest mortality being among the more extensive operations, such as vaginal hysterectomy. Abdominal operations generally carry a risk of about 1.5 per cent., and Wertheim's hysterectomy about 10 per cent.

CHAPTER XLI

OPERATIONS ON THE KIDNEY AND URETER

By JOHN EVERIDGE

I. OPERATIONS ON THE KIDNEY

Preliminary examination.—The preliminary examination in operations on the kidney involves complicated methods of diagnosis. These include cystoscopy with all its allied methods, radiography alone, urography by the excretion or ureteral catheterization technique, and estimation of the renal function. By these methods, which cannot be described here, the surgeon, before operation, should be in possession of complete knowledge about the following points:

1. The diagnosis of urinary as opposed to extra-urinary disease.
2. The differentiation of vesical, ureteral, and renal disease.
3. The localization of disease to one or both kidneys.
4. The nature of the renal disease.
5. The estimation of the extent of the renal disease.
6. The estimation of the total renal function and that of each kidney.

By the use of modern methods the diagnosis is complete before operation, and only on the rarest occasions is exploration of the kidney — formerly so common a method of diagnosis—now performed.

Preparation of the patient.—The preparation of a patient for a kidney operation involves preliminary treatment of the bowel and the renal function and appropriate measures to combat urinary sepsis.

Treatment of the bowel is important, as distension of the gastro-intestinal tract is a frequent sequel to operation on the kidney. It is a distressing, and may be a serious and even fatal complication. When the intestinal tract is already in good order, it is sufficient to empty the bowel by an efficient purge and an enema.

The purge should be given at least thirty-six hours before the operation, and should consist of an efficient dose of castor oil, or a vegetable laxative such as colocynth and hyoscyamus in a pill. Salts should not be given, as they are uncertain in action and tend to produce flatulent distension. After the purge, the diet should be moderate, and starchy foods such as untoasted bread and potatoes, green vegetables and uncooked salads, should be avoided.

On the morning of the operation the lower bowel should be cleared by a small enema.

When possible, a course of six weeks' preliminary treatment should be undertaken, to include removal of decayed teeth, thorough treatment of oral and nasal sepsis, administration of bowel antiseptics (kerol, dimol, salol, calomel), and regulation of the bowel action by vegetable aperients or liquid paraffin. For an atonic bowel, massage and electricity may be necessary.

Treatment of the renal function by diuretics, such as large quantities of water, or waters like Vittel, Contrexéville, and Vichy, may be necessary, but the administration of too much fluid is apt to produce distension of the bowel, and should on this account be carefully watched.

Urinary antiseptics should be administered as a prophylactic before many operations on the urinary tract, hexamine or the sulphonamide group being preferred. It is wiser to discontinue, thirty-six hours before major operations, all those likely to interfere with renal function, and to substitute alkalis, as a defence against acidosis and renal failure. Glucose and pre-operative drinks provide additional security.

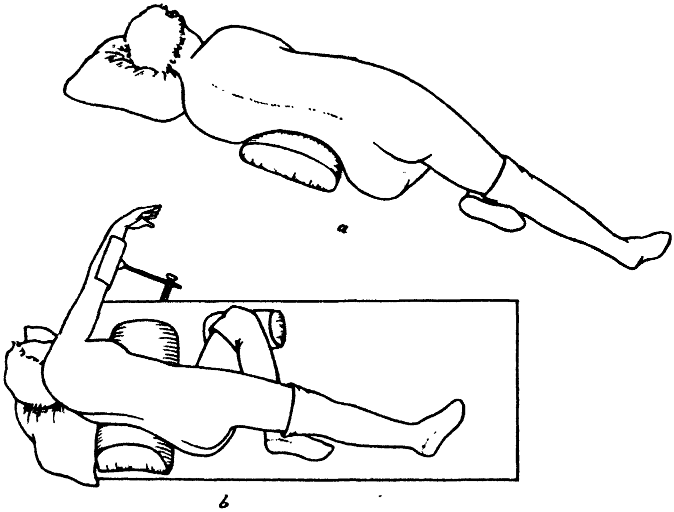

Fig. 921.—Posture for Lumbar Exposure of the kidney.

(*a*) The lower loin is raised as high as possible to procure the widest costo-iliac space.

(*b*) The lower leg is acutely flexed, and with a sandbag under the knee the tendency to rotation is overcome, the ankle being anchored under the fully extended upper thigh.

Position of the patient on the operating-table.—The usual incision for the exposure of the kidney is in the lumbar region, and the patient must lie on the sound side. In order to increase the space between the last rib and the iliac crest, a support is placed under the loin. (Fig. 921*a*.)

Edebohls' rubber air bag or the triangular air cushion originally designed by Dr. David Newman (Fig. 922*a*), or the wooden kidney wedges described by Grey Turner* may be used. Every modern operating table is equipped with some form of metal support for the loin.

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* *The Lancet*, 1926, ii, 224.

In the kidney position the lower hip and knee are fully flexed, and the upper thigh and leg extended in the axis of the body. Sand-pillows are placed in front of the upper knee and beneath the lower knee, to prevent the patient rolling. Carter-Braine's rest is used to support the arm and prevent the arm and shoulder falling forwards. (Fig. 921*b*.) This allows free play to the chest, and greatly assists the anæsthetist. The rest is a flat metal plate which is pushed beneath the under-shoulder. To this is attached a rod which carries a metal gutter on which the arm rests. (Fig. 922*b*.) The gutter can be raised or lowered.

The ventral position is sometimes used, the patient lying prone, with the head turned to one side and the arms alongside the body. In this position an Edebohls' bag is placed under the abdomen.

The dorsal position is used in abdominal exploration of the kidney.

Fig. 922 (*a*).—Newman's kidney air-cushion.

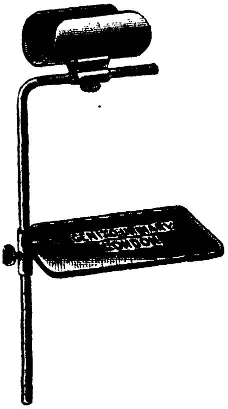

Fig. 922 (*b*) Carter-Braine's arm-rest.

Lumbar incision.—Two points form landmarks for the commencement and termination of the incision, namely the angle between the erector spinæ mass of muscle and the 12th rib, and the anterior superior iliac spine. The line of skin incision may be curved, oblique, transverse, vertical, or T-shaped. (Fig. 923.)

The curved incision makes most use of the valuable space in the loin, and can be extended forwards. The oblique incision approaches too near. and is limited by the iliac crest. The transverse incision does not take advantage of the recess between the erector spinæ and the ribs. The vertical incision gives a limited exposure. The T-shaped incision is suitable when additional space to that provided by the curved incision is necessary.

The oblique incision is used where the costo-iliac space is wide. The incision commences at the angle formed by the last rib with the erector spinæ muscle, and passes downwards to a point on the crest of the ilium 2½ in. posterior to the anterior superior iliac spine.

The transverse incision is more suitable where the costo-lumbar space is narrow. It commences at the edge of the erector spinæ mass of muscles and passes transversely forwards, midway between the crest of the ilium and the tip of the last rib, for 3 or 3½ in. A transverse incision is useful in large renal growths in children. It can be extended forwards to meet the amount of space required. It also is useful when an intraperitoneal exploration is required.

A very long oblique incision was used by the earlier surgeons, Morris, Kelly, Albarran and Israel, in exploring the kidney and ureter. This " lumbo-ilio-inguinal " incision corresponded in its upper extent to the curved incision, but continued downwards far into the inguinal region, even to the edge of the rectus abdominis. When more room is required, a short vertical incision is made upwards from the oblique wound extending sufficiently over the 12th rib.

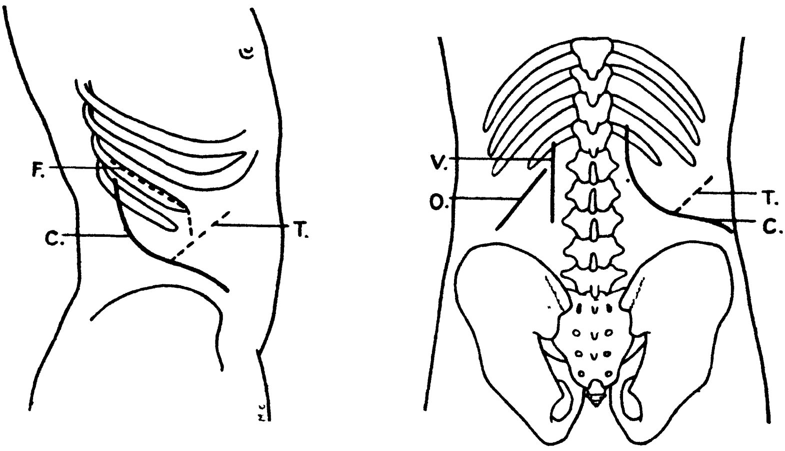

Fig. 923.—**Incisions for exposure of the kidney. C, the curved incision usually adopted by the writer ; still better approach to the pedicle may be gained by adding T, a transverse incision. V and O, vertical and oblique incisions. F, the 11th costal incision of Bernard Fey ; the anterior division of muscles is increased as required.**

The curved incision has been used by many surgeons, and has been subject to considerable modification. W. J. Mayo used a curved incision which commences at a point 2 to 2½ in. lateral to the dorsal spines, near the outer margin of the erector spinæ. The incision lies behind the 12th rib, and reaches downwards to a point ½ in. below the angle. From this point the incision passes obliquely downwards and forwards along the anterior margin of the quadratus lumborum to a point ½ in. above the crest of the ilium, thence turning forwards parallel to the iliac crest as far as necessary.

I employ a similar incision, but take the angle between the 12th rib and the erector spinæ as the indicator, and commence 1 to 1½ in. above this over the 12th rib or last intercostal space. The incision (Fig. 923), after passing vertically to a point midway between the last rib and the crest of the ilium, curves sharply outwards parallel with the crest. The importance of carrying the incision well up over the 12th rib was pointed out many years ago by Zuckerkandl. The line midway between the last rib and the iliac crest is better than the one which lies near the crest, as the latter leaves only a narrow fringe of muscle attached to the bone, which is apt to produce a weak scar and resulting hernia. Further, by traversing muscles in the intermediate line, it is usually possible to avoid division or bruising of the last dorsal nerve which is generally to be seen below the gap in the muscles entering them in the mid-axillary line. The anterior limit of this incision depends upon the amount of room required, and follows the line of Morris's lumbo-ilio-inguinal incision. The skin is undercut along both lips of the wound and retracted widely.

A vertical incision was used by Simon (1889), Czerny (1887), and Edebohls. The incision is made with the patient prone, and is placed at the outer border of the erector spinæ muscle. The exposure thus obtained is very limited, and is only suitable for operation in such conditions as movable kidney in the female subject.

Mouat draws attention * to the advantages offered by the incision of Fey† in the removal of a large kidney adherent in its upper part. This follows the 11th rib which is separated subperiosteally and dislocated downwards. The deep periosteum is incised in the same line and the incision is then carried downwards and forwards through the muscles, as required to give adequate exposure. I have found it satisfactory, but in two of my cases chest complications resulted from opening the pleura (Fig. 923).

In an oblique, transverse, or curved incision the lateral edge of the latissimus dorsi and the serratus posticus inferior are cut and the posterior border of the external oblique exposed. The external oblique and the internal oblique are divided to a varying extent, and the lumbar fascia exposed. The 12th dorsal nerve, with the accompanying subcostal vessels, is seen crossing beneath the lumbar fascia. The incision of the lumbar fascia at the lateral border of the quadratus lumborum allows the retroperitoneal fat to extrude. The fore and middle fingers are slipped through the opening and the peritoneum is separated from the inner surface of the transversalis muscle and fascia. The muscle, and as much more of the internal and external oblique muscles as necessary are divided (Fig. 924).

Attention is now turned to the upper part of the wound. If necessary, the incision through the latissimus dorsi and the serratus posticus inferior may be extended. The 12th rib is exposed and, when the quadratus lumborum and other muscles attached to its lower border are cut, is held by the external arcuate ligament. This is divided with scissors, and the rib can now be retracted upwards. In doing this the subcostal vessels are frequently cut, and are sometimes difficult to ligature owing to their proximity to the rib. A catgut

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* *Brit. Journ. Urol.*, 1939, ii, xi, 126.

† Fey, Bernard, *Arch. Urol. de la Clinique de Necker*, 1925–27, v, 169.

ligature on a curved needle should be passed round these and tied (Fig. 925).

Removal or section of the 12th rib may be considered necessary to obtain a free exposure of the renal pedicle. Mayo states that this was necessary in 51 out of 203 cases.

In a long experience of kidney surgery, Sir John Thomson-Walker only excised the rib in three of his early cases. An extension forwards of the wound will give an equally good exposure of the pedicle. A varying amount of retroperitoneal fat is exposed, and after separating this the colon is seen in the anterior part of the wound, and the perirenal fascia (Zuckerkandl's fascia) in the posterior part. Two long Spencer Wells forceps are placed close together on the perirenal fascia, which is then cut with scissors. On incising the fascia, the fine light-coloured fat of the fatty capsule of the kidney presents. The incision in the fascia and fat is continued vertically up and down, sufficient to give adequate exposure, and a fascial-fatty flap is raised from the kidney. In elevating it the colon will be carried forward as the fascial investment is separated beyond the convex margin of the kidney and its anterior surface. The further procedure will depend upon the object of the operation.

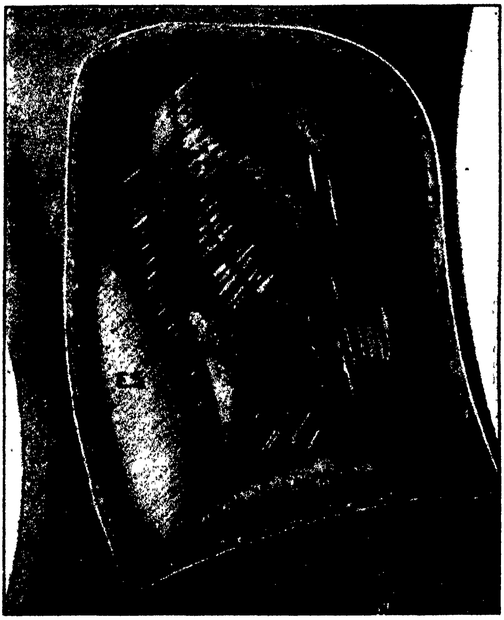

Fig. 924.—The muscle planes concerned in lumbar exposure of the kidney.

L.D., latissimus dorsi, resected to expose deeper layers. S.P.I., serratus posticus inferior. E.S., erector spinæ L.A., lumbar aponeurosis. I.O., internal oblique, resected to expose transversalis abdominis, T. E.O., external oblique. P., position of Petit's triangle. 11, 11th rib. 12, 12th rib. The dotted line indicates the position of the last dorsal nerve and the continuous line is the incision which approaches the kidney *above* the nerve, the nerve being displaced downwards and backwards.

Difficulties and dangers of the operation.—In a thick loin, with little space between the 12th rib and the iliac crest, the available area for operation may be much confined, so that the wound is a deep and narrow one. This difficulty may also be encountered when the cushion under the loin is too soft or not sufficiently high, or when it is so broad as to prop up the lower iliac crest and ribs instead of pressing well into the loin. By carrying the incision well forwards and freely retracting the muscles and turning the colon forwards out of the way, a better exposure will be obtained in a difficult case.

There may be persistent bleeding from a vein in the upper cut edge of the internal oblique. This muscle retracts upwards beneath the external oblique and disappears from view.

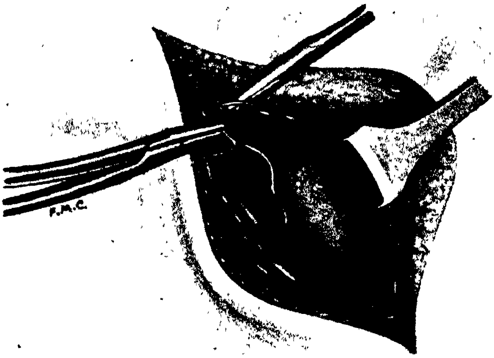

Fig. 925.—Undersewing the subcostal artery. Often required after division of the external arcuate ligament, a necessary step in the upward dislocation of the last rib for better exposure of the kidney.

Injury to the peritoneum may occur from neglecting to separate it from the abdominal wall before cutting the muscles. The opening is at the anterior angle of the wound, and a coil of the small intestine appears at this spot. Or there may be firm adhesions between the peritoneum and the anterior surface of the kidney, and in the process of separation it is opened. This is most likely in secondary operations on the kidney, and there is also danger of injuring the peritoneum at the costal margin when much scar tissue is present.

Firm adhesions to the duodenum or colon have been responsible for injury to these viscera in the process of separation of the anterior surface of the kidney and exposure of the renal pedicle.

If it is important to examine the abdominal aspect of the kidney, its vessels or lymphatics, advantage should be taken of an accidental opening into the peritoneal cavity by enlarging the gap and introducing the hand.

An opening in the peritoneum may have to be made deliberately for exploration. In this case the colon is defined, and the peritoneum picked up and incised in front of it. I have five times successfully removed a gall-bladder for cholelithiasis, and frequently the appendix, in this way. Rarely is use made to-day of this means of ascertaining the existence of an opposite kidney.

The pleura may be wounded at the upper angle of the wound. This is most likely when there is a very short 12th rib or during excision of this rib. With moderate care this is not difficult to avoid in a straightforward case. Mayo records 13 cases of injury to the pleura in 203 lumbar incisions. This large number may be accounted for by the fact that in 51 cases it was found necessary to divide the 12th rib. Should this accident occur, a gauze pack is immediately introduced into the opening, while preparations are made for suture. Closure is usually simple and is effected by introducing No. 2 catgut sutures upon a short, fully-curved needle through the edges of the gap in the membrane, including in these the muscular coverings, to give a better hold of the sutures. The approach to the pleural opening where the Fey incision was used is easy and allows ready closure.

Closure of the lumbar incision.—The muscles are united by interrupted catgut sutures, about one to the inch, passed by large curved needles. The sutures take up the whole thickness of the muscular abdominal wall, and are clipped and put aside until all are passed.

Care should be taken that the internal oblique, which always retracts upwards beneath the external oblique, is not missed by the needle.

When all sutures are passed the opposite loin is lowered, the edges of the lumbar wound fall together, and the sutures are tied. A few secondary stitches may be required to close superficial gaps.

Drainage is carried out by a medium-sized rubber tube with lateral opening or a strip of corrugated rubber. This should, if possible, be placed at the posterior extremity of the lumbar wound, and usually lies behind, or below and behind, the kidney.

In nephropexy the kidney is fixed at the posterior surface, and the drain must be anterior to the organ, and will reach the surface most easily about the middle of the wound. When the renal pelvis has been opened, the tube should lie behind the kidney, and the end is carefully adjusted to lie close to the posterior aspect of the pelvis.

It is occasionally possible to dispense with drainage in such cases as nephrectomy for tuberculous disease and for growths.

Where the renal pelvis has been opened, or nephrotomy or nephropexy done, the perirenal area must be drained to avoid accumulation of urine or blood. The objection to drainage is the discomfort and local irritation it produces and the danger of infection (usually staphylococcal) passing along the track outside the tube.

The drain is removed between the second and sixth day, depending upon the escape of urine or the persistence of oozing.

After the operation there is an area of anæsthesia about the size of the hand below the scar, due to section of the lateral cutaneous branch of the last dorsal nerve. Sensation returns in the course of a few weeks.

The patient is kept recumbent for three weeks to permit of firm healing of the muscles. Even when extensive section of the muscles has been necessary, the scar remains firm, and there is very little danger of hernia.

Transperitoneal exposure of the kidney.—This may be carried out by a paramedian incision, a transverse incision extending from the posterior aspect of the loin round to the outer edge of the rectus, or a T-shaped incision, a combination of the two former, as originally used by Rutherford Morison (p. 1911). This approach is used for very large tumours of the kidney.

After opening the peritoneum, the lymphatics of the kidney and abdomen are carefully examined, and the limits of the tumour defined. The peritoneum over the latter is incised vertically along the outer side of the colon, and this part of the bowel is retracted inwards, exposing the anterior surface and vascular pedicle.

The abdominal contents are a source of embarrassment, and cases are rare where this method of approach is to be recommended (*see also* p. 1910). It offers opportunity for ligature of the main vessels as an early step in nephrectomy for malignant neoplasms, thereby reducing the risk of operative dissemination.

EXPLORATION OF THE KIDNEY

Modern methods of investigation have reduced the value of operative exploration, and the operation is now performed only in a small class of cases.

The indications for renal exploration by operation are as follows :—

1. *Unilateral renal hæmaturia* with no enlargement of the kidney, no definitely characteristic cell elements in the urine, no shadow with X-rays, no filling defect of the renal pelvis or calyces in excretory or direct pyelography, and no history of the passage of a uric-acid calculus.

The most probable diseases in such a case are new growth of the kidney not involving the renal pelvis, or where no gross lesion of the kidney can be demonstrated, the so-called " essential hæmaturia."

2. *Renal pain* definitely localized, either recurrent or continuous, where no undue mobility, stone, new growth, hydronephrosis, tuberculosis, or pyogenetic inflammation has been found by the various non-operative methods of examination.

The most common conditions found are localized interstitial nephritis, calculus of pure uric acid, adhesions dragging on the ureter without permanent dilatation of the pelvis or calyces, moderate mobility of the kidney, or chronic perinephritis from some extrarenal cause.

Recently attention has been drawn, by S. H. Harris[*] and others, to painful dysfunction of the neuro-muscular mechanism of the renal calyces, pelvis and perhaps the ureter as well. By pyelography and pyeloscopy abnormal systole and diastole may be observed, believed to be responsible for severe colicky pains. Renal sympathectomy (*see* p. 1938) may not only relieve the pain, but is accredited with restoring, in certain cases, a natural architecture as proved by subsequent pyelography.

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[*] *Proc. Roy. Soc. Med.*, 1935, xxix, 623.

3. In *obstructive anuria* the side of obstruction may be suggested only by slight pains or discomfort, and operation takes the form of an exploration followed by nephrostomy.

4. *Renal tumours* without symptoms, which cannot be localized and diagnosed by catheterization of the ureters and pyelography, are very rare. Into this category come some cases of closed hydronephrosis, and perirenal and suprarenal growths.

5. *Bacterial inflammation of the renal parenchyma,* e.g. " carbuncle," for in many such cases a differential diagnosis from perinephric abscess was not established before operation.

Technique.—To explore the kidney it is necessary to expose it, to clear it of all adhesions, inspect and palpate it, open the renal pelvis and inspect the interior, sound the calyces with a metal probe, introduce the finger into the pelvis, incise the kidney substance and examine the cortex and medulla, examine the pelvis and calyces with one finger in the kidney wound and another in the incision in the pelvis, and finally pass a ureteric catheter down the ureter. All these manœuvres may not be necessary, but without them the kidney cannot be said to be thoroughly explored.

The curved lumbar incision (*see* p. 1888) is made, and should be sufficiently long to examine the kidney, renal pelvis, and upper ureter in position. The kidney having been exposed (*see* p. 1889), the fatty capsule is stripped off. In a favourable case the kidney can be raised into the wound and, when the vascular pedicle is long, may be delivered on to the loin. It is carefully examined with the naked eye, and is then thoroughly palpated between the finger and thumb.

The renal vessels are examined, being exposed by gentle traction. In clearing the vessels by stroking with a gauze swab it must be remembered that the veins are thin-walled and are apt to be torn unless the greatest gentleness is observed, especially in the operation of renal sympathectomy which, *per se,* requires complete denudation of all the vessels. Aberrant renal vessels, especially those passing to the lower pole and in intimate or abnormal relation to the pelvis or upper ureter, are carefully sought and noted. The kidney is turned upwards toward or over the costal margin so as to expose the posterior surface of the pelvis. This is cleared of fat, which usually lies over it, care being taken not to wound the posterior branch of the renal artery which runs parallel with and sometimes under cover of the edge of the hilum. The kidney is now given to an assistant to hold in position, or two broad strips of gauze are passed, one beneath each pole, and crossed over the convex border to use as a holder, (Fig. 926.) Two catgut sutures (No. 00) threaded on fine curved round-bodied needles are introduced close together into the posterior wall of the renal pelvis. These are held up and the wall of the pelvis is incised between them in whatever axis the nature of the operation demands ; it is usually made in a line which, if continued, would pass through the uretero-pelvic junction. A transverse incision, *i.e.* one at right angles to this line, may be preferable (*see* p. 1921). The uretero-pelvic junction can be inspected from within. A metal probe is inserted into each calyx and the recesses are sounded.

If nothing has so far been found, nephrotomy will be the next step. Bleeding from the incision in the kidney is free.

Compression of the vascular pedicle may be necessary. This may either be digital or instrumental. An assistant grasps the vessels between finger and thumb (Fig. 927), and maintains sufficient pressure to render the nephrotomy field exsanguine ; or the vessels may be grasped between the first and second fingers, and the tips of the fingers held together with the thumb and fingers of the free hand.

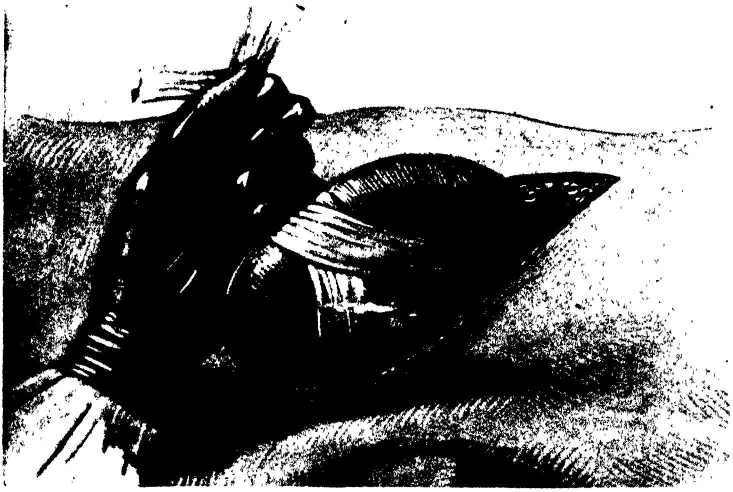

Fig. 926.—Exploration of renal pelvis : method of holding kidney.

When the kidney cannot be delivered from the wound, there is not sufficient room in the wound for the hands of the assistant. The operator grasps the renal pedicle with the thumb and forefinger of the left hand, and at the same time steadies the organ.

Instrumental pressure gives a completely exsanguine field of operation, but the renal pedicle may be damaged, and there is a tendency, in the complete absence of bleeding, for the surgeon to go too far in laying open the renal substance, and to overlook the fact that large vessels are being cut through, with the result that very severe and sometimes uncontrollable hæmorrhage may follow the removal of the clamp or Roberts lung-hilum tourniquet, and may even necessitate nephrectomy. On the other hand, the sutures necessary for the control of the severe bleeding may destroy a large part of the renal parenchyma.

The incision into the kidney substance is made in the convex border just posterior to the most prominent line of the border. In this line, as Brödel has shown, there is less likelihood of meeting large vessels, for the anterior and posterior systems of blood supply are arranged in relation to the anterior and posterior groups of calyces, which lie in front and behind this line. The incision should be vertical to the surface, and the direction in which it is deepened is guided by the finger and thumb of the left hand, which grasps the renal pedicle. The cut surface of the renal parenchyma is carefully examined. Usually one or two calyces are opened, and the lining mucous membrane is seen. The forefinger of the right hand is introduced into the wound and enters the pelvis. A metal probe may be introduced to search for calculi (*see also* p. 1917). It is sometimes necessary to search the pelvis and calyces with both hands; in this case the left forefinger fills the nephrotomy wound and temporarily controls the bleeding, and the right forefinger is introduced into the wound in the renal pelvis and meets the finger of the left hand in the pelvis.

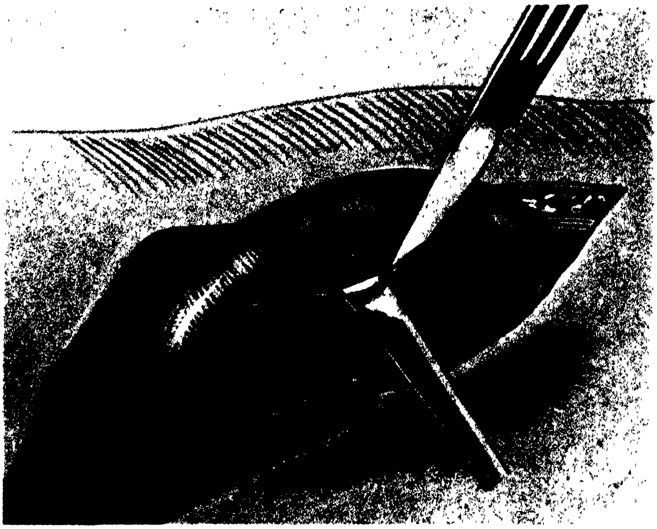

Fig. 927.—Nephrotomy : pedicle compressed by thumb and fingers.

Before closing the wound in the kidney it may be advisable to cut a slip of kidney tissue from one of the lips of the wound for biopsy.

The kidney wound is closed by catgut sutures threaded on large curved or straight round-bodied blunt-pointed needles. Thick catgut (No. 4) which is not too wiry or hard should be used. One or two mattress-sutures or figures-of-eight are introduced at a distance of about 1½ in. from the edge of the wound ; this will control the vessels near the base of the pyramids from which the most important hæmorrhage takes place. A second row *en échelon* may be required ½ in. nearer the edge of the wound.

Care must be taken that the fibrous capsule of the kidney is not disturbed during the exploration, as this holds the sutures which without it would cut through the friable tissue of the kidney. If the capsule has been accidentally separated during previous manipulations it will be necessary to adapt pads of muscle or fat to buffer the hold of the mattress sutures. The various methods of closing an incision made into the renal substance are shown in Fig. 928.

The sutures are tied slowly and gently, only sufficient pressure being exerted to control the hæmorrhage. If the sutures are tied too tightly, they are apt to cut out and cause postoperative hæmorrhage.

If it is impossible to expose the renal pelvis a ureteric bougie may be passed from the nephrotomy wound at the upper pole. It should not be passed from the incision at the lower pole, for the upper calyx is in line with the pelvis and ureter, and the lower calyces lie below the level of the pelvis and uretero-pelvic junction.

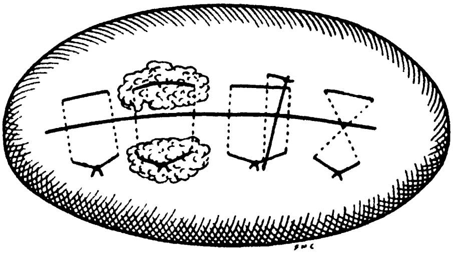

Fig. 928.—Methods of closing nephrotomy incision (numbered from left to right).

- (i) A mattress-suture.
- (ii) A mattress-suture tied over buffer pads of fat or muscle.
- (iii) A plain suture tied over a mattress-suture which prevents the plain through-and-through stitch from cutting into the renal substance.
- (iv) The figure-of-eight suture.

Transverse incisions are sometimes suitable for operation on some lesion that has been recognized, such as a stone felt through the renal substance, but not for a general exploration of the kidney.

DECAPSULATION OF THE KIDNEY

This operation is practised in some cases of non-infective nephritis, especially the type now known as nephrosis, characterized by high albuminuria and extensive œdema, but uncomplicated by nitrogen retention and cardio-vascular changes. Eclampsia appears to have benefited little, if at all, by this operation.

The kidney is exposed by a short incision; it is not necessary to deliver it into the wound (*see* p. 1888). A small incision is made in the capsule, and a blunt dissector introduced beneath the capsule along the outer border of the kidney. The capsule is cut with scissors along the groove, and the incision carried round each pole. The capsule is then picked up with fine forceps and gently separated with a spatula, care being taken not to tear the kidney tissue nor to detach portions of the cortex with the capsule. The latter is stripped anteriorly and posteriorly as far as the hilum, and clipped away. A good deal of oozing occurs from the stripped surface, but there is no serious bleeding. Perinephric fat is removed to provide a more vascular bed, for one object of the operation is to give an additional blood supply.

If the oozing is persistent, a small drainage-tube may be inserted down to the kidney, and the lumbar wound closed. Difficulty may arise from adhesion of the capsule, and in cases of contracted kidney from long-established interstitial nephritis this is not infrequent. In nephrosis the capsule strips with ease.

Bilateral operation is necessary where decapsulation is employed. Both kidneys are usually decapsulated at one sitting, but occasionally it may be considered necessary to defer operation on the second kidney until the first wound is healed.

NEPHROPEXY

The operation of nephropexy is justified where symptoms or pathological conditions are present that can be assigned to the mobility of the kidney. A movable kidney that is part of a general enteroptosis is unsuitable for operation unless pain is very definitely referred to the kidney and is unrelieved by other methods. Where there are known to be extensive adhesions of the bowel and a movable kidney, the case is seldom suitable for nephropexy.

The cases suitable for nephropexy are patients with undoubted movable kidney, where there is pain referred directly to the kidney, or where the attacks known as Dietl's crises occur, and especially if urography shows hydronephrosis. Nephropexy should only be done for mobility when every other source has been clearly excluded, and even so it must be combined with a careful exploration. A common combination is pyelitis with movable kidney. Here the pain may be relieved and medicinal treatment employed to better advantage if the kidney is so fixed as to provide a freer escape of urine. Intermittent hydronephrosis is an indication for nephropexy. In the early stage, before the kidney is felt enlarged on palpation, pyelography will demonstrate the dilatation.

Where pain is the only symptom present, it is relieved by rest in bed in full recumbency in all cases likely to be permanently alleviated by operation. This should be used as a test for the suitability of the case for nephropexy.

Since stasis is now well recognized as a factor in the ætiology of stone, it is advisable after many operations for removal of stone to attach the kidney to its bed in such a way as to ensure perfect drainage. Fixation is equally necessary after plastic operations for hydronephrosis, and after symphysiotomy of a horseshoe kidney (*see* p. 1942 and Fig. 929).

The operation consists in the suspension or fixation of the kidney, either by the use of structures already present in the body, or by the production of inflammatory tissue that will become fibrous, or by the use of foreign material. A very large number of operations have been introduced, many of which are only slight modifications of previous methods. For information on these, the surgeon is referred to the older text-books.

Technique.—A curved lumbar incision is made of sufficient length to expose the 12th rib and give free access to the kidney and its surroundings (*see* p. 1887). Dilatation of the renal pelvis, kinking or narrowing of the uretero-pelvic junction, adhesions, and aberrant vessels are all excluded by thorough examination.

The surface of the quadratus lumborum and of the psoas is completely cleared of fat and areolar tissue by stroking it downwards with a dry gauze swab. The kidney is delivered from the wound and turned over the lower ribs with the posterior surface displayed. With a light touch, the fibrous capsule is incised so as to include an area of the posterior surface extending from pole to pole and from the hilum to within an inch of the convex border. The capsule is raised with forceps and gently stripped backwards from the edge parallel to the outer border of the kidney towards the hilum. (Fig. 929.) At points along the incision and where the capsule dips into a fissure between congenital lobules, scissors will be required.

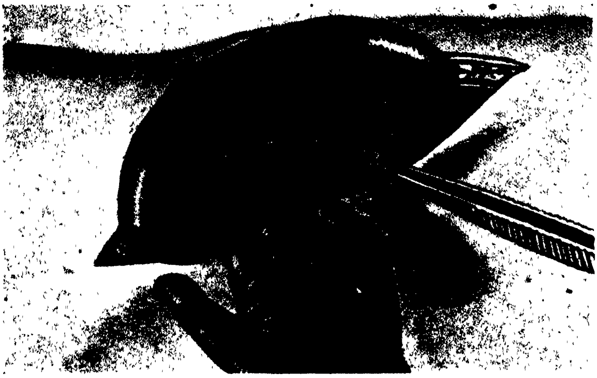

Fig. 929.—Nephropexy : stripping of capsule on posterior surface of kidney.

That part of the capsule which has been stripped back to the edge of the hilum, is cut away. Three sutures of supple No. 4 catgut are passed through the kidney substance about ¾ in. from the convex border, and within the area of attached capsule. The upper suture lies near the upper pole, the intermediate about the middle of the convex border, and the lower near the lower pole.

The kidney is now replaced, and the surgeon carefully fits it into the position in which it lies most easily. The upper pole will be beneath the 12th rib, the denuded area will lie upon the bare quadratus muscle. The surgeon is careful to see that the upper pole is not tilted outwards, and the ureter and pelvis are examined with the kidney in position to see that there is no kinking.

Each end of the catgut sutures is threaded on a large curved, round-bodied needle. The upper suture is passed through the structures at the angle of the last rib and erector spinæ muscle, or sometimes is carried through the last intercostal space and is then tied. The posterior end of the second suture is passed through the quadratus muscle near its outer edge and tied to the anterior end, and the ends of the lower suture are similarly treated (Fig. 930, *see also* Fig. 953 and Plate VIII.) Partial fixation of the kidney which permits a range of movement is a common source of failure ; the organ should be completely fixed to the posterior abdominal wall.

Should there be much oozing from the stripped surface it is advisable to place a drain on the anterior surface, extending to the lower pole. Tihs drain will lie about the middle of the lumbar wound. The muscles are united with interrupted catgut sutures, and the skin with a continuous suture of thread or silk. The tube, if used, is removed in twenty-four hours. The patient is kept recumbent in bed for three weeks, and then allowed up without any abdominal support.

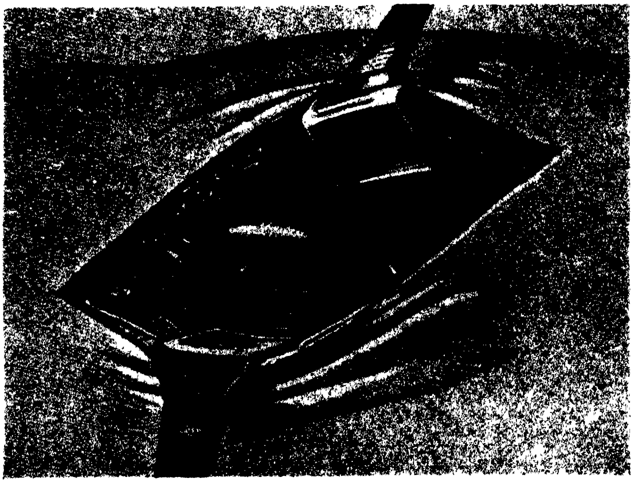

Fig. 930.—Nephropexy : kidney stitched to surface of quadratus lumborum. The sutures should be of stout catgut, not silk as shown.

Results.—The mortality of this operation is stated as 1 per cent., but it is probably now much lower. Failure may consist in the persistence of symptoms, or the kidney may become loose again.

NEPHRECTOMY

Nephrectomy may be performed by the lumbar or the abdominal route ; it may be extracapsular or subcapsular, partial or total, primary or secondary.

Indications.—1. *New growths of the kidney.*—All new growths of the kidney necessitate the removal of the organ if cure is to be effected. In malignant growths no doubt exists of the propriety of complete nephrectomy. Simple growths of the kidney comprise adenoma, papilloma of the renal pelvis, and angioma. It is not possible to find and completely remove papillomata of the renal pelvis by nephrotomy. Short of nephrectomy there is no method of complete cure. Angiomata are very rare, and give rise to serious hæmorrhage. The diagnosis of an angioma from a malignant growth is nearly always uncertain at the time of operation.

2. *Renal tuberculosis.*—Nephrectomy is the only certain cure for unilateral tuberculosis of the kidney, and should be performed in all cases unless some contra-indication is present.

3. *Renal calculus.*—Removal of the kidney is indicated in advanced cases of unilateral renal calculus, where the stone is so large or branched that removal would destroy the remaining kidney tissue or early recurrence would be almost certain ; in unilateral renal calculus, where the kidney is destroyed by obstruction (calculous hydronephrosis) or sepsis (calculous pyelonephritis or pyonephrosis) ; and in calculus complicated by new growth.

In bilateral calculus nephrectomy should, if possible, be avoided. If in this condition it is imperative, from complications such as infection, the more healthy kidney should first be relieved of its stone. Where there is advanced bilateral calculous disease, operation of any kind is better avoided, unless for the relief of some symptom such as severe hæmaturia or pain. Nephrotomy, nephrolithotomy or permanent nephrostomy would be preferred to nephrectomy.

4. *Pyonephrosis and renal carbuncle.*—Where the general condition of the patient is satisfactory and the second kidney is healthy, primary nephrectomy should be performed. If these conditions are not fulfilled, nephrostomy, followed later by nephrectomy, is the best course.

5. *Pyelonephritis.*—In hæmatogenous pyelonephritis, causing severe hæmaturia, nephrectomy may be necessary, subject to the same conditions as in pyonephrosis. In ascending pyelonephritis, nephrostomy is to be preferred to nephrectomy in most cases, as bilateral infection is usually present.

6. *Hydronephrosis.*—Nephrectomy is only performed where it is impossible to deal with the cause of obstruction, or where the organ is completely destroyed.

7. *Urinary fistulæ* following operation on the kidney or ureter.

8. *Injury.*—Nephrectomy may be indicated at the time or later.

9. *Cysts.*—Large single cysts and hydatid cysts may necessitate nephrectomy. In a large single cyst free removal of the sac may suffice, while in hydatid cyst marsupialization is frequently preferable. Polycystic disease being almost invariably bilateral, nephrectomy is seldom indicated.

10. *Complications such as uncontrollable hæmorrhage during or following an operation on the kidney.*

11. *Hypertension.*—On the supposition that a unilateral poorly-functioning ischæmic kidney manufactures a pressor substance. (Based on Goldblatt's experiments.)

12. *Ectopic kidney.*—If causing troublesome symptoms.

Contra-indications.—1. *Conditions affecting the diseased kidney.*—Malignant growths may be widely adherent, or the growth may have spread to glands or invaded surrounding structures. In such cases the full extent of the growth may only be discovered during the operation, and experience and judgment are necessary to decide whether removal of the kidney is possible.

2. *The second kidney is the seat of disease or is incapable of carrying on the renal function.*—In tuberculosis and calculous disease the condition is bilateral in the late stage in a large proportion of cases. Nephrectomy is then contra-indicated. In bilateral tuberculosis the cause of death in the great majority of cases is uræmia from destruction of renal tissue. The removal of one of two tuberculous kidneys may hasten this result. Exception, however, may exist in bilateral cases where one kidney is, by all the usual methods of urological investigation, functionless, the seat of tuberculous destruction and therefore the source of toxic absorption, whilst the other kidney is identified as diseased only by a tubercle bacilluria and shows no anatomical or physiological defect. In the writer's experience in many of such cases after removal of the destroyed kidney general health has improved, cystitis has resolved and the presence of tubercle bacilluria after a varying interval could no longer be ascertained.

3. *General condition of the patient.*—In diseases such as pyonephrosis, pyelonephritis, and tuberculosis of the kidney there may be profound toxæmia such as to contra-indicate so extensive an operation as nephrectomy. In such cases nephrostomy will be performed, and nephrectomy carried out later.

Active tuberculosis of the lungs or of bones or joints may contra-indicate nephrectomy. Metastatic deposits of renal growths are also a contra-indication. Exceptionally, however, removal of a large renal growth may be considered justified as a palliative measure, even when there is evidence of secondary deposit.

Preliminary examination.—It is necessary that certain information should be in the possession of the surgeon before nephrectomy is performed, e.g. (1) the functional capacity of the second kidney; (2) whether the second kidney is diseased. The usual tests for renal function, and careful X-ray examination of the second kidney in renal calculus, should never be omitted; excretion urography provides a quick and reliable means of ascertaining the state of the opposite kidney, but this method has obvious limitations in the presence of any form of urinary infection. The surgeon must also know (3) whether the disease has spread beyond the kidney, and (4) whether there are deposits elsewhere.

LUMBAR NEPHRECTOMY

The curved incision already described (p. 1887) is preferred by me for lumbar nephrectomy. Where the kidney is large, high and fixed it is necessary to divide the external arcuate ligament and the fibres of the serratus posticus inferior, and by pulling on the rib there is no difficulty in dislocating it upwards. The steps for the exposure of the kidney have already been described (p. 1889).

If the kidney is widely adherent and there is some difficulty in separating it, the ureter should be exposed below the lower pole. The ureter is stripped up, grasped by two pairs of curved Moynihan forceps, isolated by means of gauze packing, cut across just below the level of the lower pole of the kidney, and touched with pure carbolic, or division and cauterization may be combined by the use of the high-frequency knife. The lower end is tied below the pressure-forceps and dropped into the retroperitoneal plane. Where primary nephrectomy for tuberculosis is being performed, the ureter is divided and ligatured at the lowest level the wound will permit. The remains of the duct are separated as far as possible and displaced downwards into the pelvis ; by so doing subsequent ureterectomy, if ever necessary, will be simplified. Treatment of the ureter is further discussed on p. 1946. The upper end of the ureter, still in the grasp of the pressure-forceps, serves as a guide for further blunt separation of the kidney and its pedicle from their surroundings. In stripping up the ureter it will be remembered that as a rule the vessels of the renal pedicle lie in front of the ureter and pelvis, and none of them behind these structures.

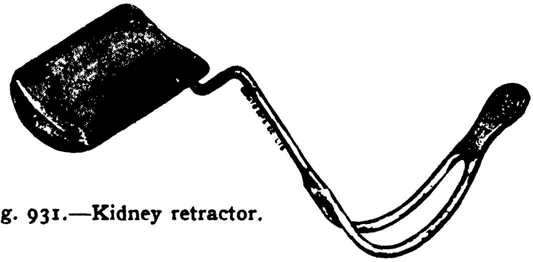

Fig. 931.—Kidney retractor.

The anterior surface of the kidney is further stripped of the fatty capsule and the anterior surface of the renal pedicle exposed, the veins coming first into view. With the hand and dry gauze swabs the kidney is gradually separated until the upper pole is reached, where its adhesion to the suprarenal capsule will be felt and may be seen.

The suprarenal capsule is separated and its inner margin will be found to lie in contact with the upper and outer vessels of the renal pedicle. The upper pole of a large diseased kidney may be densely adherent to the under-surface of the diaphragm and in part to the liver, and much difficulty may be met with in separating these dense adhesions.

A fold of peritoneum lies over, and is adherent to, the upper part of the anterior surface of the kidney, where the adhesions may be very dense. This interferes with the complete exposure of the vascular pedicle, and the adhesions must be fully separated before dealing with the pedicle. Free exposure by means of an efficient kidney retractor (Fig. 931) and good illumination are important at this stage.

Lower down, the retroperitoneal surface of the colon may require careful stripping from the anterior surface of the kidney.

Over the anterior lip of the hilum and the anterior aspect of the vascular pedicle on the right side lies the second part of the duodenum.

This structure may be injured during nephrectomy, and in difficult cases it is best deliberately to expose it in order that it may be avoided.

The kidney on its anterior and posterior aspects and at each pole having been separated, attention is turned to the pedicle. The pedicle is grasped between the first and second fingers of the left hand, from above downwards on the right side and from below upwards on the left side. The assistant retracts fully, and prevents the peritoneum and the bowel from falling over the pedicle. The pedicle is cleared by stroking with dry gauze. Difficulty may arise from the matting of the tissues around the vessels with thick fibrous fat.

Large lymphatic glands to which the vessels and fat are firmly adherent make the pedicle stout and thick, and when much chronic inflammation is present the whole pedicle forms a thick rigid mass. Time taken in reducing the size of the pedicle by removing adherent peritoneum, thick fibrous fat, and sometimes a lymphatic gland, is well spent. Usually the lymphatic glands are so embedded and adherent as to make their removal impossible.

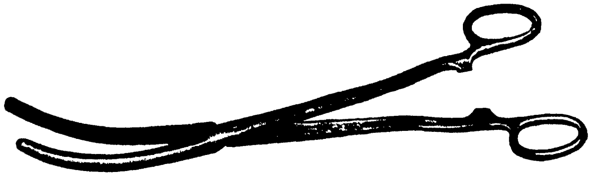

Fig. 932.—Renal Pedicle Clamp. This type is used by the author in two sizes, a larger and heavier to grasp the deep part, a lighter size for the part of the pedicle adjacent to the kidney. Division is made close to the outer clamp, see also Fig. 933.

A curved pedicle clamp (Fig. 932) is now slipped, with the blades widely open, over the pedicle, just to the central side of the fingers, care being taken to include all the vessels if possible ; if some, however be at a distance from the main mass they must be grasped separately in powerful artery forceps. On the right side the clamp will pass more easily from below, on the left side from above. If the pedicle is broad, a second clamp may be applied from the opposite direction, but usually careful work will reduce the pedicle to a size readily grasped by one clamp. A lighter clamp is placed on the pedicle close to the kidney, preferably as much as one inch from the former clamp to prevent, when the pedicle is divided, soiling of the wound with blood from the kidney, or septic material from an accidentally torn pelvis. (Fig. 933.) The pedicle is divided close to the outer clamp, leaving a broad fringe distal to the inner clamp, in which the great vessels are seen and which are, in turn, picked up in artery forceps.

A double strand of No. 2 catgut is placed round the whole pedicle deep to the inner clamp and drawn up as tightly as possible, but not permanently tied. A second double catgut strand is now placed mesial to the first and this is gradually and forcibly tightened as the assistant very slowly releases the clamp. When the clamp is removed this (the second) ligature should have been tightened to its utmost, and the second knot tied. The slack ends of the first ligature are then drawn tight and knotted. The artery forceps placed on the great vessels in the fringe may now be removed, assuming that the surgeon is satisfied that he has secured perfect hæmostasis and no doubt exists of the integrity of his ligatures. The first ligature collects the elements of the pedicle into a bunch, the clamp often keeping them rigidly spread out at the distal end. As the clamp is opened, the second ligature closes up the elements of the pedicle still further, and exerts full pressure on all the vessels. The first ligature may be quite loose after the second has been tied. These manipulations are very carefully and gently carried out, without dragging on the clamp, and without

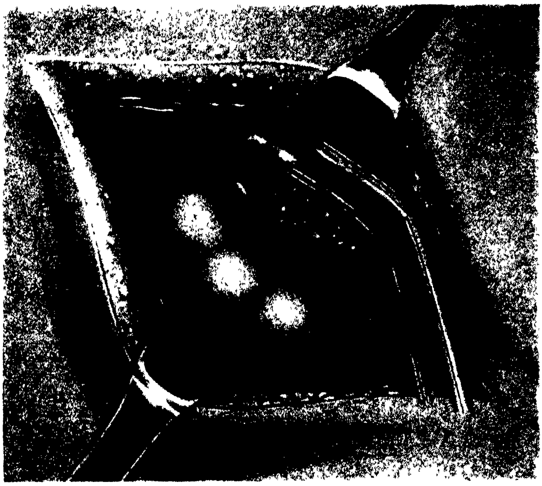

Fig. 933.—Application of Pedicle Clamps.—Division of the pedicle is made close to the outer clamp in order to leave a fringe of tissue beyond the inner clamp substantial enough to give purchase for forceps placed on the great vessels. In this case nephro-ureterectomy was performed for pyonephrosis and pyo-ureter with large stones impacted at the vesical end of the duct, which is seen to be markedly dilated.

levering it against the edge of the wound. When the clamp is removed and the ends of the ligatures are cut, the pedicle will be seen fully exposed in the open wound.

When the pedicle is densely infiltrated with inflammatory material so that it cannot be reduced to a size that will be safely grasped by a circular ligature, it is tied in two parts. After the kidney has been removed, the clamp is steadied by an assistant and a blunt pedicle-needle passed through the mass just central to the clamp, being assisted by pressure of the finger on the opposite side of the pedicle.

The double strand is then tied round each half of the pedicle. If there is doubt of the efficiency of the ligature, a second ligature may be passed in the same way. The important part of the pedicle is usually in the grasp of the upper ligature.

After the clearing away of clots and loose tags from the depth of the wound, the muscles are brought together and the skin united.

There are certain points that require further discussion :

1. **Perinephric fat and vessels.**—In chronic inflammatory diseases great masses of thick fibro-fatty tissue lie round the kidney, and a good deal of this will be removed during the operation. The removal of as much of the fat as possible is important in tuberculous disease of the kidney, for tuberculous foci, which may be microscopic in size, are usually present in it and may lead to persistent sinuses after the operation.

In malignant growth of the kidney all the perinephric fat should if possible be removed.

In growths there may be many large veins coursing in the perinephric fat, injury to which causes considerable hæmorrhage. These veins are most abundant on the anterior surface and towards the lower pole. Large pressure-forceps are placed on the veins, but the operation should not be prolonged at this stage by meticulous care in arresting this venous bleeding as it will cease when the pedicle is controlled.

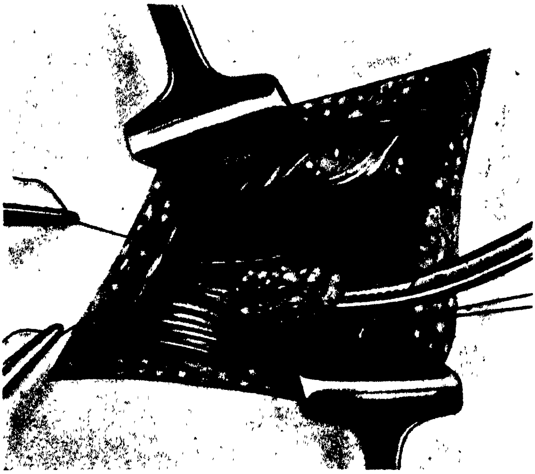

Fig. 934.—Nephrectomy (right). Having cut across the vascular pedicle close to the distal clamp, the fatty fringe is seen projecting beyond the proximal clamp. The first ligature, shown as a single strand, is in situ, but not tied (see text). The ureter has been ligatured.

2. **The ureter.**—Several methods of dealing with the ureter in tuberculosis of the kidney are described (*see* under Ureterectomy, p. 1954).

3. **Pedicle.**—The ligature is sometimes passed through the pedicle on a pedicle-needle before removing the kidney and without using a clamp. The pedicle is then ligatured in two parts, the strands interlocking. Where the kidney is large this procedure must be carried

out wholly by touch, and it is in using this blind method that most of the accidents from slipping ligatures and from the non-inclusion of large vessels in ligatures have occurred.

Leaving clamps on the renal pedicle was at one time a comparatively frequent method, and is, in very rare cases, still considered necessary. As a rule the necessity arises from incomplete exposure through too small a wound, and want of care in reducing the size of the pedicle. If this method must be used, the handles of each pair of forceps should be tied with thick silk to provide against the risk of their springing open. The clamps are taken off after forty-eight or seventy-two hours. They should be loosened in the first instance and not actually removed until some three or four hours later. A sloughing and infected wound and a tedious convalescence sometimes follow.

Where the pedicle remains large and its approach, owing to the presence of the large kidney, renders application of the pedicle-clamp difficult or unsatisfactory, a Roberts' lung-hilum tourniquet may be used to control the vessels while the kidney is removed. The vessels may then be picked up and tied individually.

4. **Drainage.**—In some cases of nephrectomy the wound can be closed without drainage. Where much oozing of blood is feared, or there has been soiling of the wound with pus or tuberculous material, a rubber drainage-tube should be inserted at the upper angle. It is removed in forty-eight hours.

ALTERNATIVE METHODS OF NEPHRECTOMY

1. **Grégoire's operation.**—This operation * attempts to remove the kidney with its glands and the surrounding fatty and areolar tissue *en bloc*. It appears, however, to present little, if any, advantage over the T-shaped approach (*see* p. 1888).

The incision is made vertically in the anterior axillary line from the costal margin to the iliac crest. At its upper extremity it curves forwards and upwards, following the costal margin for 5 cm., at its lower extremity it passes forwards along the crest of the ilium for 5 cm.

The layers of the abdominal wall are incised as far as the peritoneum. Posteriorly, the surface of the muscles is followed, separating the perinephric fascia and its contents with the fingers. Anteriorly the line of reflection of the parietal peritoneum is defined and the perirenal fibrous capsule incised along this line. The peritoneum and the colon are then displaced forward by blunt dissection.

The kidney is thus isolated anteriorly and posteriorly within the perinephric fascia. The vessels are exposed, and tied close to the vena cava and aorta, and the ureter ligatured and cut. The kidney, with surrounding fatty capsule and its lymphatics, is then removed in a single mass.

2. **Subcapsular nephrectomy.**—Subcapsular nephrectomy is performed in inflammatory diseases of the kidney (pyonephrosis, tubercu-

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* *Presse Méd.*, Jan 25, 1905, xiii, 49.

losis) when there is such a massive, firmly adherent fibro-fatty capsule that it cannot be removed.

The perirenal fat is exposed and incised, and the convex border of the kidney is seen. The fibrous capsule of the kidney is incised longitudinally and raised on one side, and the forefinger introduced between this and the renal cortex. The finger is then swept over the surface of the kidney anteriorly and posteriorly and at each pole, the fibrous capsule separating easily from the kidney cortex. The kidney, stripped of the capsule, lies loose within its fibro-fatty covering. The incision in this covering is extended downwards with scissors, and the whole capsule laid open. It is not possible, owing to the rigidity of the structures at the pedicle, to draw the kidney into the wound.

The chief difficulty in subcapsular nephrectomy is the pedicle, which is surrounded by a mass of fibro-fatty tissue. The capsule is stripped well forwards and backwards to the hilum. When this has been carried as far as possible, a thick broad pedicle remains, consisting of the renal vessels and the pelvis and upper ureter, all covered by the reflected fatty tissue. Dissection of the pedicle and upper ureter may now be carried out, or may be deferred until the kidney is removed. The procedure will depend on the size of the kidney and the freedom of the exposure. A large kidney with a poorly-exposed hilum is better treated by removal of the kidney first and dissection afterwards.

In the dissection of the pedicle an incision is made through the fibro-fatty tissue, and the ureter identified and followed upwards. By further dissection the vascular pedicle is exposed.

A powerful pedicle-clamp or lung-hilum tourniquet is applied and the kidney cut away. In cutting the pedicle the scissors will frequently have to cut through kidney tissue, portions of which may be left on the stump in the grasp of the clamp. If the kidney has been removed before dealing with the pedicle, further dissection of the pedicle should be made. A circular incision is made round the pedicle through the fibro-fatty tissue and prolonged downwards along the line of the ureter. With care, the renal vessels are thus exposed and the upper ureter isolated. Ligatures are placed on the vessels, either in a single mass or in two parts, by transfixing the pedicle with a pedicle-needle. If possible, the ureter and remains of the pelvis should be separated from the pedicle after removing the clamp, and care must be taken to cut away any portions of kidney tissue which have been left on the pedicle.

If the condition of the patient admits, much of the fibro-fatty tissue can be dissected away from the lower and middle areas of the wound. The wound is freely drained.

A fragment of renal tissue, even though it be quite small, if left may be sufficient to cause a permanent fistula. Subsequent removal of such a fragment would be an operation of the utmost difficulty, hence every effort must be made at the primary operation to prevent such an omission.

3. **Partial nephrectomy.**—Removal of a part of the kidney has been suggested, and was at one time practised for tuberculosis. Fuller

knowledge of the pathology of renal tuberculosis shows, however, that it is not possible to remove all the disease without performing complete nephrectomy.

Partial nephrectomy may be employed for injuries, cysts, non-malignant new growths, or fistulæ, and may be combined with partial removal of the pelvis in certain cases of hydronephrosis (Albarran's orthopædic resection).

The first deliberate attempt to remove a portion of the kidney was made by Czerny in 1887. Goldstein and Abeshouse, reviewing 296 cases of renal resection,* regard the essential features of the operation as: (i) the correct surgical approach; (ii) careful preparation of the vascular pedicle with ligature of the vessels to the segment to be removed; (iii) decapsulation in the operation area and utilization of this portion of the capsule in closure of the wound. The portion of the kidney substance removed should be wedge-shaped, so that the two cut surfaces can be applied to each other when the wound is closed by suture.

The risk of hæmorrhage is considerable where the renal substance is extensively incised. The endothermy cutting-current limits bleeding from the smaller vessels, but the larger vessels should be undersewn with a round needle rather than controlled by the coagulating current. Neither the endothermy nor the diathermy current precludes the possibility of reactionary or secondary hæmorrhage. I have twice removed solitary cysts larger than lemons situated in the body of the kidneys by dissecting out their capsules, which had impinged against the central calyces. In neither case was the endothermy current available and consequently fat grafts (as hæmostatic agents) from perinephric fat were placed between the opposing surfaces of the cut kidneys as they were drawn together by mattress-sutures. In two further cases I dissected out with the endothermy knife similar large central cysts, also involving calyces, in one of which a calyx stone was also present. Post-operative hæmorrhage was negligible in each of the four cases and all healed *per primam* without fistula formation in spite of wide openings into the calyces.

Removal of the upper or lower element of a double kidney is frequent to-day. It presents no especial difficulties apart from the need for precaution in analysing the vascular supply of each element with meticulous care. Overlap and interlacing of vessels may lead to confusion so that failure to recognize the precise arrangement will sacrifice the healthy element. A depression of fibrous stratum may indicate the line of cleavage. Division is made in cuneiform fashion to facilitate closure of the remaining section.

Occasionally it is advisable to remove a pole, generally the lower, after ligature of an abnormal polar artery (*see* p. 1931); a similar method is adopted and, again, the high-frequency knife is a great asset.

4. **Secondary nephrectomy.**—Secondary nephrectomy is undertaken where one or more operations have previously been performed,

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**Journ. Urol.*, July, 1937, xxxviii, I, 15.

such as the removal of stones, or where the kidney has been drained. Such cases are pyonephrosis, pyelonephritis, and tuberculosis of the kidney with secondary infection. There is usually a sinus or a fistula which is infected.

A full curved incision should be used, and may follow the line of the scar or cross it. It encircles the fistula, which is dissected out. The scar tissue obliterates the layers of the abdominal wall. The muscles at the anterior extremity of the wound will be recognized, and the wound deepened here to expose the peritoneum. Care should be taken at the posterior part of the wound to avoid wounding the peritoneum, which may lie far back and be firmly adherent.

Here also there is a danger of cutting into the kidney, which lies directly under and adherent to the posterior part of the scar. When the peritoneum is recognized, it is dissected forwards off the anterior surface of the kidney. The lower pole is isolated and the ureter sought and dissected up. Dense adhesions will be found binding the kidney to the lower rib margin, and the peritoneum may inadvertently be opened in cutting through this layer.

Posteriorly the kidney is adherent to the quadratus and psoas muscles, and care should be taken not to strip up a layer of these muscles with the kidney. At the upper and anterior aspects the kidney is, as a rule, less densely adherent, and a good vascular pedicle is usually obtained.

The steps of the operation follow the lines already laid down.

It may be found at the early part of the operation that removal of the kidney with its capsule is not possible, and a subcapsular nephrectomy must be performed.

Not infrequently an operation which is partly intracapsular and partly extracapsular will result.

5. **Transperitoneal nephrectomy.**—The two conditions under which the transperitoneal route is indicated are (1) injuries to the kidney where it is suspected that other abdominal viscera are involved, (2) large growths of the kidney.

For the latter the curved lumbar incision with the transverse extension (p. 1888) gives all the advantages of a transperitoneal operation with the exception of ligature of the main vessels as an early step, before manipulation and mobilization of the kidney. Those in favour of the transperitoneal operation stress the value of early vascular control as a protection against operative dissemination.

The incision may be placed in the middle line, or be paramedian, or in the linea semilunaris (Langenbush's incision). In very large growths the paramedian incision is preferable. The intestines are packed off and the parietal peritoneum is incised along the outer border of the colon and several centimetres from it. The colon is displaced inwards, exposing the anterior aspect of the kidney and the renal pedicle.

The ureter and vascular pedicle are exposed by further dissection. The ureter is clamped and ligatured, and the vascular pedicle isolated, clamped, ligatured in two segments, and cut across. The extirpation of the kidney proceeds partly by blunt dissection and partly by clamp and ligature of vascular adhesions. Care is taken to remove all the perirenal fat in which the renal lymphatics lie. Any abnormally enlarged glands are removed by dissection.

A stab-incision is made through the muscles of the loin, and a drainage-tube introduced. The colon is replaced, and as far as possible the peritoneum repaired. Rutherford Morison originally favoured a T-shaped incision. The abdomen was opened vertically in the linea semilunaris and a second incision was carried transversely backwards in the ileo-costal space towards the loin. When the introduction of the cystoscope removed the need for manual examination of the other kidney, he discontinued the vertical section and only retained the transverse part. An incision of this type may have advantages in the removal of the largest renal neoplasms, especially where extensive adhesions are suspected and perinephric tissue is also to be removed.

Difficulties and dangers of nephrectomy.—1. Difficulties incidental to **the type of patient and the character of the disease** are frequently encountered.

The patient may be stout and the ilio-costal space narrow. Widespread adhesions may require prolonged and careful dissection. A voluminous gas-distended colon sometimes fills up the wound, and is more troublesome if the anæsthesia is incomplete or if the anæsthetic is difficult to administer.

The vascular pedicle may be naturally short, and may in addition be thick and rigid from inflammatory infiltration and enlarged glands.

2. **Hæmorrhage.**—Venous hæmorrhage may arise from the large veins covering a malignant growth. The ovarian or spermatic veins lie in close relation to the ureter. They should be isolated and if necessary ligatured. These veins sometimes give rise to difficulty in ligaturing a short renal pedicle, and full exposure and ligature below the kidney before dealing with the vascular pedicle may save much trouble later. Arterial hæmorrhage may result from the tearing of an aberrant artery. It is only likely to cause difficulty at the upper pole, and with moderate care this accident is easily avoided.

Hæmorrhage from the renal pedicle is usually due to failure to include all the vessels in the ligature, or to slipping of the ligature. Such accidents as tearing the kidney off the vascular pedicle are due to want of judgment in placing too great tension on the kidney, to undue haste, or to carelessness.

The preparation and method of ligature of the pedicle is the most important part of the operation of nephrectomy, and neither time nor trouble should be spared in carrying it out.

Tearing of the inferior vena cava is followed by the welling-up of dark venous blood in the wound. It is readily controlled by finger pressure, and, after clearing away the blood, the torn portion is picked up in forceps and sutured with fine catgut. If the hole cannot be satisfactorily ligatured or sutured, a pressure clamp may be left on;

it must not be removed sooner than the third day after operation. The after-history of such cases is satisfactory.

Hæmorrhage after the operation may be due to faulty application of the pedicle ligature, or to sepsis. Both are very rare, the latter occurring most frequently in sepsis following injuries.

3. **Injury to the pleura.**—This is shown by the whistling of air at each respiration. It is more likely to occur where the 12th rib is rudimentary or where the rib is removed. (*See* p. 1892.)

4. **Injury to the bowel.**—In separating the colon from the kidney, dense adhesions or a localized abscess may be found, and tearing of the bowel has been described. Sloughing of a portion of the bowel previously involved in the perinephric inflammation may follow operation. In such cases the fistula closes as the wound granulates, and operations to close the opening should not be attempted unless a permanent fistula has formed.

Mayo describes injury to the second part of the duodenum by the pedicle-clamp in right-sided nephrectomy. He recommends an abdominal operation for the closure of the fistula. If such an injury is detected at the time it must be repaired by suture.

5. **Shock.**—Profound shock, due to the length of the operation, to dragging on the sympathetic nerves related to the renal pedicle, and to loss of blood, may result from nephrectomy, and may be present at the end of the operation, or may become acute three or four hours after the patient is returned to bed.

At the end of a long operation, the cavity from which the kidney has been removed should be filled with hot saline solution before the wound is closed. The usual remedies for postoperative shock are adopted.

6. **Distension of the stomach or the colon.**—These are frequent and troublesome complications after kidney operations, and especially after nephrectomy. After operation an early action of the bowel should be ensured by castor oil. Saline aperients should be avoided. Gastric dilatation will require lavage.

7. **Uræmia.**—Uræmia was at one time the most frequently fatal postoperative complication of nephrectomy. It is very rare in urinary surgery at the present day, as the result of early diagnosis of renal disease, and the more careful selection of cases for nephrectomy which is possible by modern methods of pre-operative examination.

Uræmia is treated by rectal, subcutaneous, or intravenous saline or glucose infusion, preferably by the " drip " method, free purging, and hot packs or radiant-heat baths.

GENERAL SURVEY OF RESULTS OF NEPHRECTOMY

Whilst mortality provides the item of primary statistical interest and considerations of operative results seldom go beyond it, with the exception of nephrectomy for cancer and tuberculosis, the state of persons with only one kidney, recognized of importance by Ellis and

Weiss[*] has to be considered as well. Hanley[†], in a study of 213 nephrectomized patients was able to trace 182 for periods up to six years. His findings may be briefly summarized :—

	Mortality		*State in survivors traced*	
	Operative	*Total* (up to 6 yrs.)	*No.*	
Hydronephrosis (40 cases)	5%	10%	29	50% showed R.F. sub-normal. Many c/o contra-lateral pain, and pelvic dilatation shown.
Pyonephrosis (44 cases)	20%	34%	24	38% showed R.F. sub-normal ; 12% renal failure Contra-lateral pain and pelvic dilatation in 50%.
Calculous pyonephrosis (49 cases)	6.1%	16.3%	40	75% showed R.F. sub-normal.
Tuberculosis (48 cases)	4.1%	22.9% (with 6 yrs.)	31	33% cystitis lasting 3 yrs. 33% non-renal tuberculosis. Over 30% retained T.B. in urine, and a further 20% B.C.C. cystitis. 54% showed R.F. sub-normal.
Neoplasms (27 cases)	22%	63% (within 2 yrs.)	8	R.F. good.

R.F. = Renal Function

Ellis and Weiss found a lower incidence of depressed renal function, their result being 41·6 as compared to the 56 per cent. of Hanley. The last adopted the usual tests (estimations of blood-urea and non-protein nitrogen, MacLean's urea-concentration test and Van Slyke's urea-clearance test) ; most reliance was placed in the clearance test.

Compensatory hypertrophy.—Insufficient data are as yet available by which this may be reckoned. Contra-lateral pain may be some evidence that the surviving kidney is working to the full. Radiographic enlargement of renal outline and, it seems, some dilatation of the renal pelvis, is common, but no reasonable explanation of the last phenomena is, so far, to be found. According to these means of assessing hypertrophy, age bears no influence ; animal experiments, however, have proved the reverse : that hypertrophy is active in the young and meagre in old animals.

Results of nephrectomy.—i. **Mortality.**—The operative risk of *lumbar nephrectomy* will vary proportionately to the size and fixation of the kidney and the constitutional state of the patient. In favourable cases an immediate mortality of no higher than 2·5 per cent. is to be expected. Adverse factors may raise the mortality rate to over 20 per cent. For the high mortality of war wounds associated injuries are, in the main, responsible.

In nephrectomy for *calculi*, infection is a governing factor. Rafin, surveying the results of eight surgeons, found no mortality in 25 cases for uninfected calculi, but 7·5 per cent. in 155 infected cases, many of which, it may be assumed, were adherent pyonephroses.

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[*] *Amer. Journ. Med. Sci.*, 1933, clxxxvi, 2, 242.
[†] *Brit. Journ. Surg.* 1940, xxvii, 107, 553.

The immediate mortality of nephrectomy for *renal tuberculosis* was found to be 4 per cent.*, such deaths as occur having generally been ascribed to the tuberculosis rather than to the trauma of operation. A follow-up of 369 nephrectomized patients (German Urological Congress, 1911) showed 15·2 per cent. to have died in the subsequent 16 years; 10·6 per cent. having died in the first two post-operative years. More recent statistics offer a no more optimistic outlook; indeed, in cases traced over a period of five years, it appears that a recovery rate better than 60 per cent. cannot reasonably be expected. Possibly, now that nephro-ureterectomy is being more systematically adopted, future statistics will be more favourable. The more radical operation seems to add little to the immediate risk, and in a personal series of 24 nephro-ureterectomies (now considerably increased) there was no operative mortality.† A series of 50 nephrectomies for tuberculosis also showed no immediate mortality.

In **renal neoplasm** immediate mortality mirrors the progress of major surgery through the last half century; apparent retrogression indicated in the more recent figures may be ascribed to more accurate assessment and greater boldness in the attack upon cancer. Thomson-Walker‡, tracing the decline in mortality, gives the following interesting comparisons:—

1885.	Minges	85 per cent.	
1888.	Tuffier	65 ,,	
1902.	Albarran and Imbert	22 ,,	for connective tissue tumours, and 15 to 20 per cent. for tumours of the pelvis.

Schmieden's § personal review of 329 cases shows comparable results:

In the first ten years of renal surgery, mortality of 64·3 per cent.
,, second ,, ,, ,, ,, ,, 43 ,,
,, third ,, ,, ,, ,, ,, 22 ,,

Transperitoneal nephrectomy before 1890 showed a higher mortality than lumbar (50 as compared with 37 per cent.), the difference being mainly due to septic complications; since that date, however, the figures are reversed, death rate from the lumbar operation being greater in the proportion of 23 to 21·1 per cent., according to Albarran and Imbert‖. Trendelenberg and Riedel, who both employed the transperitoneal route, claimed even better results: 20 and 11·1 per cent. respectively. It is questionable if better figures for the operation, when performed for hypernephromata, could be claimed to-day; if, however, tumours of the renal pelvis are included, many of which are simple and nephrectomy almost a minor operation, no more than a 10 per cent. mortality from lumbar nephrectomy should be expected.

Thomson-Walker, *Brit. Med. Journ.*, October, 1927, ii, 625.

. *Roy. Soc. Med.*, 1940, xxxiii, 295.

‡ Genito-Urinary Surg., Cassell & Co., 1914, 1st Ed., p. 202.

§ *Deuts. Zeits. f. Chir.*, 1902, lxii, 205.

‖ *Les Tumeurs du Reins*, Paris, 1903.

H. G. Hanley[*] found the post-operative mortality in 27 cases of neoplasm, patients of different surgeons, was 22·2 per cent.

Nephrectomy for *adeno-sarcomata* (Wilm's tumours) shows a high operative mortality, 25 to 30 per cent.

ii. **Ultimate results.—Incidence of recurrence.**—*Tumours of the Parenchyma in Adults.* Thomson-Walker (*ibid.*) and Legueu[†] agree that recurrence is found in 60 per cent. of those who recover from the operation, the majority (70 per cent.) showing metastases in the first year ; the incidence of relapse diminishes with each succeeding year. Israel[‡], reviewing his results to 1909, recalls that, of his 124 nephrectomies for malignant neoplasm, the operative mortality was 22·2 per cent. ; 32·6 per cent. of the survivors (that is 27·7 per cent. of the original 124 cases) were free of recurrence after three years, and 35·9 per cent. of these (namely, 25 per cent. of the total) could be regarded as cured, since they showed no sign of recurrence after five years. Voelcker in 1920[§] shows very similar results. J. T. Priestley[||], reporting results from 1910 to 1936, states that of the 482 survivors of the 568 operated for renal growths : (*a*) with hypernephromata, 47·7 per cent. had lived three years, 38·4 per cent. five years, and 27·3 per cent. ten or more years ; and (*b*) with epitheliomata, the figures were almost the same except beyond the ten-year span. Bull[¶] gave details of 24 survivors of nephrectomy for hypernephroma ; 11 have lived more than 3 years, 5 are alive without recurrence, 13, 12, 8, 8 and 3½ years ; 3 died from recurrence 6¾, 4 and 4 years after operation, 1 is alive with recurrence 12 years after operation and 2 died from other causes 7 and 4¼ years post-operatively.

Wilm's tumours.—G. Neumeyer[**] reported 7 operated cases in every one of which there was death from recurrence within five months. Of 756 recorded, only 17 lived 5 years after operation. In a personal case a female child aged 14 months, from whom I removed an adeno-sarcoma of the left kidney 4½ inches in diameter, died 10 years later from osteomyelitis of the tibia ; a full autopsy gave no evidence of recurrence or metastases.

Hypernephromata and Wilm's tumours show a high degree of radio-sensitivity, and it is to be hoped that radiation may, in due course, offer better prospects of cure.

NEPHROLITHOTOMY

In nephrolithotomy one or more calculi are removed from the kidney by cutting through the renal parenchyma.

Preliminary investigation.—Certain information must be in the possession of the surgeon before he embarks on the operation.

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[*] *Brit. Journ. Surg.*, 1940, xxvii, 107, 553.

[†] Traité Chir d'Urol., 2nd Ed., 1921, p. 1149.

[‡] Chir. der Niere und des Harnleiters, 1925, p. 454.

[§] Die Neubildungen der Niere in Kraus und Brugsch. Bd. 7.

[||] *Journ. Amer. Med. Assoc.*, 1939, cxiii, 902.

[¶] Klinische Erfaringen Om Hypernephrom, 1913–1933, Oslo, 1935.

[**] Zentralbl. f. Chir. 1939, lxvi, 1330.

1. **The calculus.**—The X-ray shadow must not only be proved a renal calculus by its radiographic characters ; its position must be accurately localized by the relation it bears to the pelvis and calyces, shown by pyelography, and to an opaque catheter introduced into the pelvis. Non-opaque calculi may produce a filling defect of the renal pelvis or blot out a calyx ; such calculi may retain a coating of urographic medium for a short while after its introduction and so reveal themselves. It is my custom to order a radiographic examination on the day of operation, on account of the elusiveness of smaller calculi.

2. **The affected kidney.**—Palpation may demonstrate enlargement where there is hydronephrosis, pyonephrosis or massive perinephritis. Excretion urography will show anatomical and physiological defects by comparison with the healthy side. A localized renal hydronephrosis caused by obstruction of a calyx calculus should be noted. Cystoscopic observation of the character of effluxes from the affected kidney, especially if coloured by a preliminary intravenous injection of indigo-carmine, and collection of the two kidney urines for comparison of urea percentages, as well as of pathological contents, will reinforce clinical and radiological observation.

Indications for nephrolithotomy.—This operation is performed with reluctance by urological surgeons of experience on account of the not inconsiderable risk of late hæmorrhage. The tendency to-day is to refrain from removal of the smaller calculi embedded in calyces where radiography appears to show little prospect that the calculi can be grasped from and withdrawn through the pelvis. Such calculi are often " silent " stones, causing no pain and no pathological changes within the kidney, and operative removal may cause more renal damage than the stones ever will. But when there is pain, recurring hæmaturia, localized hydronephrosis (shown by excretion urography), casts and pus in the urine collected by ureteric catheter, nephrolithotomy may be required. A branched calculus not having caused renal destruction severe enough to indicate nephrectomy, or if present in a single functioning kidney, is generally removed by nephrolithotomy, unless methods such as those described by Marion or myself (p. 1924) be adopted. Calculi in the pelvis of a pyonephrotic kidney are occasionally removed by nephrolithotomy, the opening thus made being better adapted for nephrostomy, a more suitable method for the application of antiseptics and sustained drainage than pyelostomy being in this way established (*see* p. 1929).

Technique.—The kidney is exposed by a curved lumbar incision (p. 1888) and is mobilized. It is important, before incising the kidney, to free it from its attachments and draw it as far as possible into the wound, to facilitate control of the vascular pedicle. The kidney and renal pelvis are carefully palpated, and the stone may at once be felt. If in the pelvis, pyelolithotomy will be carried out. If it is felt in the kidney and cannot be manipulated into the pelvis, the pedicle is grasped near the hilum between the forefinger and thumb of the left hand, and an incision, made in the renal cortex just posterior to the most prominent line of the convex border, is deepened on to the stone, over which the knife is felt to grate. The length of the incision depends upon the previously ascertained size of the stone.

Fine, long dissecting-forceps, or Thomson-Walker's stone-forceps (Fig. 935), are introduced into the wound, and the blades manœuvred round the stone, which is grasped and gently extracted. Great care must be taken to avoid crushing or breaking the stone, as even a small piece chipped off and left behind may form the nucleus of a new calculus. A scoop or the forefinger of the right hand may be required to loosen the stone from its bed. It should be examined for facets or fracture, indicating that other stones or fragments have still to be removed. The stone should be compared with the X-ray film, and if there is any discrepancy between the shadow and the size and shape of the stone, a renewed search in the calyx and pelvis must be made.

Several stones may be present, and an extension of the incision may be necessary, or other incisions may have to be made. If a stone is felt near the surface on the anterior or posterior aspect of the kidney, an incision is made directly over it, radiating from the hilum. On the whole, however, the incisions that give best access are those on the convex border. Where the stones are multiple, careful study of the X-ray film, and repeated search in the calyces and renal pelvis with the finger and with the probe, are necessary before concluding that all have been removed.

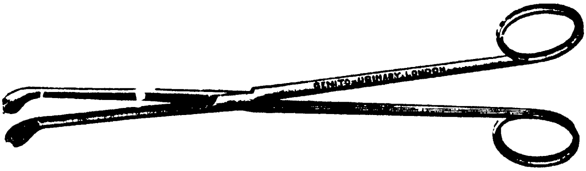


Fig. 935.—Thomson-Walker's renal stone-forceps.

A ureteric bougie may be passed through the pelvis and down the ureter, in search of small obstructing calculi. But with modern X-ray work and the passage of ureteric catheters before operation, this is rarely necessary. If residual fragments are suspected or sepsis is present, the calyces and pelvis should be washed out with a stream of weak nitrate-of-silver solution (1 : 20,000) before closing the incision in the kidney.

When a small stone shadow has been seen with X-rays and is not felt on palpation, the kidney is held between the fingers and thumb of the left hand and the blunt end of a fine straight needle or a grooved steel probe is pushed through the capsule in the line of the convex border, and at the level at which the shadow is shown in the film (Fig. 936). The instrument is pushed on into the renal pelvis, and, if nothing is felt, another spot over a calyx is probed. This method, if

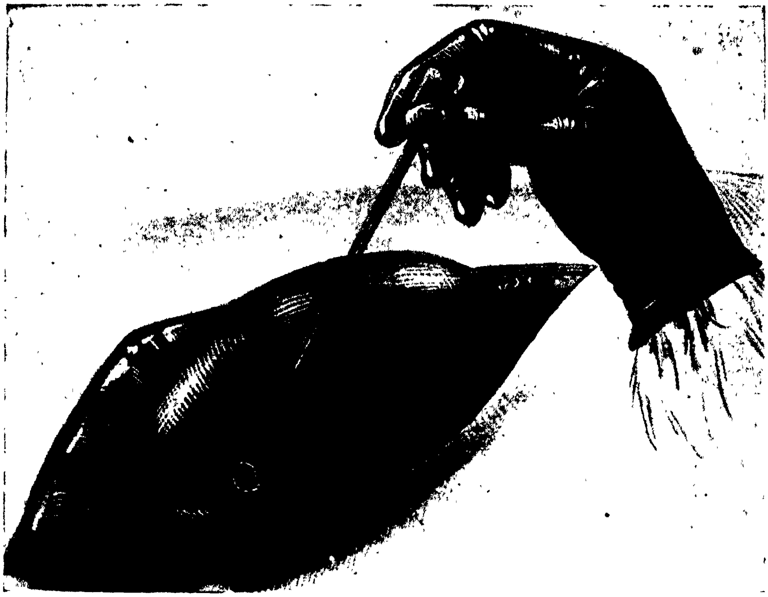
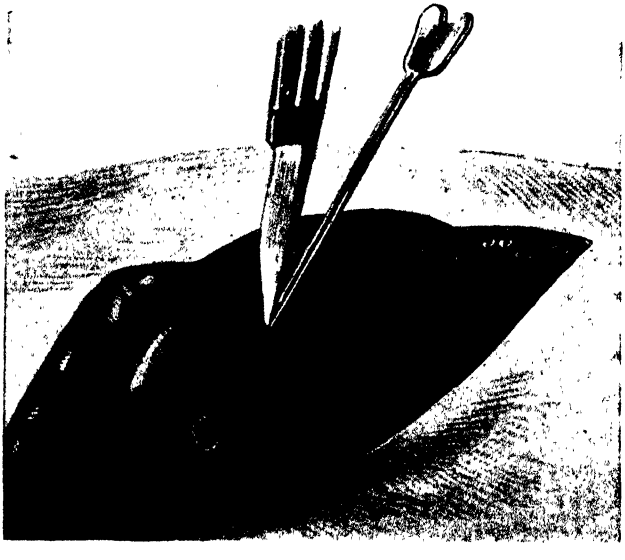


Fig. 936.—Nephrolithotomy : exploration with grooved probe.

systematically used, usually reveals even a small calculus ; if, however, it does fail, a probe may be passed up into the çalyces through a small opening made in the renal pelvis, and in this way the various culs-de-sac may be sounded. A combination of these two methods seldom fails to find the stone. When the probe is felt to grate against the



937.—Nephrolithotomy : incision on to stone along grooved probe.

calculus, it is held by an assistant, and the knife slid along the groove down to the calculus (Fig. 937). The fine stone-forceps follow, and the stone is removed through a very small opening with a minimum amount of destruction of kidney tissue (Fig. 938). One, or at most two, interrupted sutures and a single mattress-suture will suffice to close the wound, if closure be considered desirable. Many, notably Cabot and Marion, hold that complete closure aggravates the tendency to late hæmorrhage and they prefer, therefore, always to drain the calyx by a tube, the deep end of which lies in the pelvis, for two or three days to ensure absence of tension upon the kidney substance from a retained collection of blood. This is especially advisable in the presence of sepsis or where trauma has been unavoidable.

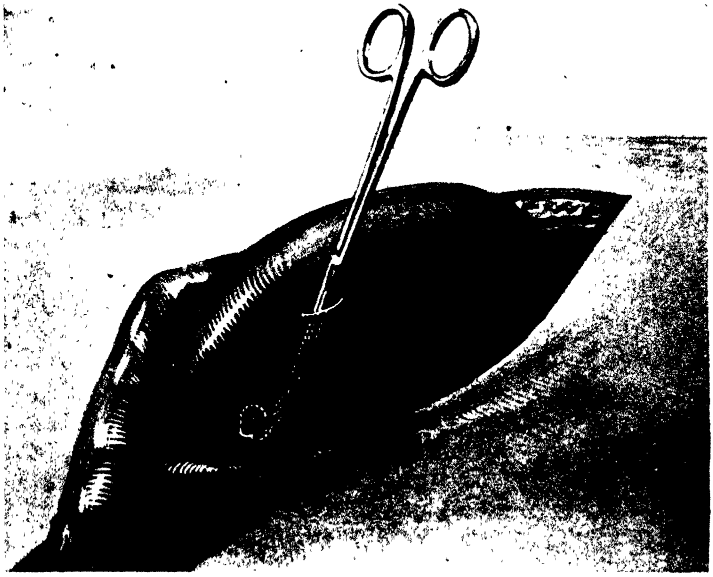


Fig. 938.—Nephrolithotomy : removal of stone.

Where a calculus has eluded search after incision of the kidney, it may be necessary to introduce a finger through an incision in the posterior wall of the pelvis and then continue the search with one forefinger in the pelvis and the other through the nephrotomy wound. In other cases the pyelotomy has first been performed, and a nephrotomy is done to extend the exploration. Radiography of the kidney (fluoroscopy) during operation for stone, first suggested by Hurry Fenwick, has been developed at the Mayo Clinic and is of use in searching for small stones that have eluded the finger and probe of the surgeon, or in displaying fragments left behind after removal of a calculus. The method consists in screening the kidney raised up on the loin, or placing a small film suitably protected in the depth of the wound when the kidney cannot be raised up to the surface.

The method involves special X-ray apparatus and an expert screener whose eyes are dark-adapted by suitable spectacles. The operating surgeon would have little prospect of recognizing minute shadows on a fluorescent screen in the operating theatre.

Where dilatation of the calyces and pelvis is present in varying degrees of pyonephrosis, every pocket must be searched for stone, the kidney thoroughly washed out with silver-nitrate solution, a drainage-tube inserted through a dilated calyx and into the pelvis, and the kidney so drained for at least a week. Daily irrigation of the pelvis is carried out through the tube, or continuous drip irrigation established, a counter-opening being made in another of the dilated calyces into which a tube is tightly sutured. In this way the whole kidney is kept thoroughly flushed out, and I have, on several occasions, kept such a system working for a fortnight.

Dangers and complications.—The dangers include those of any kidney operation, and have already been described (p. 1891), but bleeding requires especial emphasis.

Hæmorrhage is the danger especially associated with nephrolithotomy. It may occur during or after the operation. With finger control of the renal pedicle the operation may have proceeded smoothly until after the kidney sutures have been applied, when it may be found that the hæmorrhage continues and quickly distends the pelvis. The introduction of additional mattress-sutures may be sufficient to control the bleeding, but it may be necessary to remove the kidney. Postoperative hæmorrhage may escape from the drainage-tube or pass down the ureter, or it may collect in the perirenal space if this is badly drained. The hæmorrhage may become serious the day after operation, and in this case is due to incomplete control of the vessels by the sutures. It may occur four or five days, or as late as ten days after the operation. Makkas described 10 cases of postoperative hæmorrhage of secondary type; in 3 the hæmorrhage occurred on the eighth day, in 2 on the seventh, and in 1 on the ninth. If the temperature is raised, the hæmorrhage is due to swelling and softening of the kidney tissue from inflammation, which leads to tearing out of the ligatures (Marion). In aseptic cases late hæmorrhage is due to the sutures giving way about the tenth day.

The conditions likely to cause postoperative hæmorrhage are: (1) Imperfect control of the vessels. (2) Tying the sutures in the kidney too tightly, so that they cut out. (3) Stripping the capsule so that the sutures do not hold. (4) Sepsis imperfectly drained. (5) Early absorption of the sutures. (6) Tension upon renal tissue from a hæmatoma or retained products of sepsis.

Postoperative hæmorrhage should be carefully watched by taking note of the amount of hæmaturia, the local condition of the operation area and the general state of the patient. Increasing pallor, an unsatisfactory blood picture and a falling blood pressure call for prompt action; it is customary to-day to resort to blood transfusion before alarming effects arise Happily this will often stop bleeding, but if it does not do so quickly no time must be lost in exploring the kidney. Hæmorrhage may be controlled by opening the kidney and packing it with gauze, but in the majority of cases where the hæmorrhage is severe, a rapid nephrectomy is the best treatment. Nicolich found nephrectomy for postoperative hæmorrhage necessary in 4 out of 36 nephrotomies.

PYELOLITHOTOMY

Pyelolithotomy is the removal of a calculus through an incision in the renal pelvis.

To carry out this operation, certain conditions are necessary. The stone must be of moderate size—neither very small nor very large—and situated in the pelvis, in the upper end of the ureter, or in a calyx or calyces accessible from the pelvis. A rigid short pedicle and a narrow thick loin will make the operation difficult, and may render it impossible.

Technique.—The kidney is exposed and drawn out into the wound, and is turned upwards and forwards to display as fully as possible the posterior aspect of the pelvis. It is then held in position by the assistant with the aid of gauze slings under each pole (*see* Fig. 926, p. 1895). Care must be taken to avoid too powerful traction on the slings, as the atrophied pelvic wall may rupture at the site of stone impaction (*see* p. 1922).

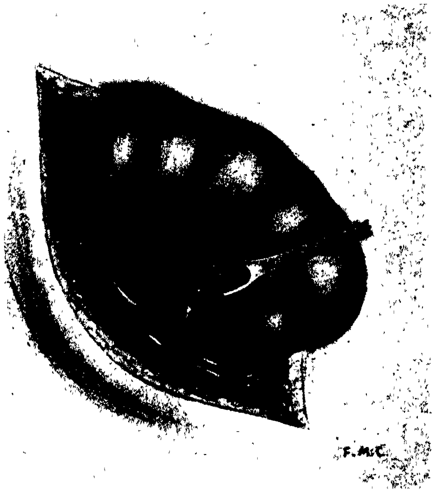


Fig. 939.—Right Pyelolithotomy.—A transverse opening is made in the pelvis to avoid the possibility of dividing the posterior branch of the renal artery (held aside by a retractor) and of encroaching on the uretero-pelvic junction.

The kidney having been drawn up and rolled over, a coating of fibrous fat will be found adherent to the posterior surface of the pelvis. This is incised at the lower part of the pelvis and reflected upwards, exposing the muscular wall. With the opposite index finger exerting counter-pressure, an incision is made in this wall in the long or transverse axis of the pelvis, when the knife will grate against the stone. Fine forceps or a scoop are introduced and the stone carefully removed.

On account of two possible dangers of this operation, hæmorrhage and stricture at the uretero-pelvic junction, I prefer a transverse incision parallel to the long axis of the kidney, as avoiding these possibilities (Fig. 939). Hæmorrhage arises from division of the posterior branch of the renal artery, which runs transversely on the posterior aspect of the pelvis, often hidden by the posterior lip of the hilum. A vertical incision, if continued too high, may involve the vessel, ligature of which may be difficult. A stricture results from carrying a vertical incision too near the pelvic outlet. The dangers of a vertical pyelotomy are necessarily greater when the kidney cannot be delivered, and the operation has to be performed in the depth of the wound.

A stout pliable probe, bent almost at a right angle, is used to sound the pelvis and each of the calyces for other stones. The finger may also be introduced into the pelvis. A ureteral bougie is passed down the ureter into the bladder to ascertain if obstruction from stone or stricture is present. The edges of the wound in the renal pelvis are picked up with long fine forceps and brought together with stitches of fine catgut, each stitch taking the muscular coat and avoiding, as far as possible, penetration of the mucous membrane. A continuous stitch of fine catgut may be used, but I prefer a minimum number of interrupted sutures not too closely placed, as these are less likely to interfere with the vascularity of the edges.

The flap of fat is now replaced over the wound and held by a stitch. The slings are removed and the kidney returned to its bed. A drainage-tube is inserted with the terminal opening in the neighbourhood of the wound in the renal pelvis so as to provide a track to the surface for any urine that may escape.

Occasionally a stone located by pyelography as in the pelvis is found at operation to have escaped into a calyx, from which it can generally be removed with a narrow scoop. If the kidney, after separation, be gently squeezed the stone can sometimes be returned into the pelvis so that by these methods the more damaging operation of nephrolithotomy may be avoided.

When the kidney cannot be delivered into the wound, the operation may still be carried out if the stone is of moderate size. In such a case the kidney is grasped in the left hand with the fingers in front of the pedicle and the thumb on the posterior surface of the pelvis. By pressure with the fingers, the pelvis is made prominent under the thumb, and the stone can be felt. Without actually seeing the posterior wall of the pelvis, a scalpel may be passed behind the kidney and a small incision made over the stone, and this is enlarged by long-bladed dissecting-forceps and the stone removed. No stitching of the wound in the pelvis is possible, so that especial care must be taken, when the kidney is replaced, to lay the end of the drain close to the opening in the pelvic wall, to prevent accumulation of urine outside the pelvis. When the pelvis has been stitched the tube should be retained for four days. There is usually no leakage of urine, and on removal of the tube the track at once heals. When no stitches have been introduced, drainage may be free for five or six days, and will then begin to diminish ; in this case the tube is gradually shortened and may be removed about a week after the operation.

Dangers and sequelæ.—1. **Rupture of the pelvis.**—The wall of the pelvis may have been so thinned that traction on the kidney, or even the mere weight of the kidney, may be sufficient to break it away from the ureter. This was the experience in a case of mine. End-to-end suturing with drainage of the renal pelvis through a nephrostomy incision was successful; a ureteric catheter was used as an internal splint, its distal end being passed down the ureter and its proximal carried through the nephrostomy wound and attached to skin alongside the nephrostomy tube. Its presence as a guide facilitated the pelvi-ureteral suturing. Primary union took place, as shown by the absence of a urinary fistula.

2. **Hæmorrhage** from the posterior branch of the renal artery should not occur if the kidney has been easily delivered and the adherent fat properly separated from the posterior surface of the pelvis. If the artery is divided under the lip of the hilum, artery forceps cannot grasp the bleeding points. The procedure, then, is to under-sew some distance on either side of where the vessel was divided, taking up in the stitches an adequate amount of pelvic wall and the lip of the hilum.

3. **Perinephric extravasation of urine.**—If the area behind the pelvis is not drained, or is imperfectly drained and urine leaks, it may accumulate outside the pelvis in the perinephric cellular and fatty tissues, and certain symptoms arise. Hiccough commences, at first at intervals, and later becomes constant; it is distressing and, if continued, becomes exhausting. There is distension of the colon and occasionally nausea and vomiting. The temperature is not raised unless the urine is septic. After several days urine usually discharges from the wound, and the symptoms at once subside. There is delay in healing, and a fistula may form.

4. **Fistula.**—Fistula after pyelolithotomy is due to (1) obstruction at the ureteropelvic junction or in the ureter, from an overlooked calculus or stricture; (2) sepsis; (3) lack of drainage. The last is the most frequent cause. If urine is allowed to accumulate outside the pelvis, a cavity with rigid walls is formed, and into this the pelvic wound opens. The urine gradually finds its way to the surface, and a track with thick fibrous walls is created and becomes a urinary fistula. The frequency with which fistula follows pyelolithotomy has been overstated. The danger is avoided by examining for and removing obstruction, clearing up sepsis, and carefully placing a drainage-tube in relation to the pelvic wound. In 15 cases of pyelotomy recorded by Marion, 8 were not sutured and recovered rapidly; 7 were sutured, and 5 of these recovered without escape of urine, 1 had a fistula for three weeks, and 1 a permanent fistula. Bazy sutured the pelvic wound in 11 out of 16 cases, and in 5, for various reasons, he could not suture it. In the 11 sutured cases, 9 recovered very rapidly and without incident. In the 5 unsutured cases 1 had no escape of urine, 1 had a fistula for thirty days although the urine was aseptic, in 1 there was a discharge of urine for several days, and in the remaining 2 the recovery was uneventful.

5. **Stricture** of the ureteropelvic junction may follow removal of

a large stone through too long a vertical incision encroaching upon the ureteropelvic junction. A stricture will require periodic dilatation (cystoscopic) or plastic surgery (p. 1932).

OPERATIONS FOR PELVI-RENAL CALCULI

Proof of the greater safety of pyelolithotomy having been established (*see* p. 1925), a calculus should be removed by this means if possible with very few exceptions. A stone lying in a calyx may have its base close enough to the pelvis to allow some part of it to be grasped by forceps or caught in a scoop through a pelvic opening. Sometimes the neck of the calyx may be stretched with narrow-bladed angular forceps and the stone coaxed out. Gentle squeezing of the whole kidney may expel a stone into the pelvis, as already mentioned (p. 1922).

But the problem which sometimes must be faced is how to attack a pelvi-renal branched calculus, perhaps in a single kidney, the other having been removed previously for stones or destroyed by them. The danger of hæmorrhage after nephrolithotomy is so real that the surgeon may shrink from taking the risk. In one such case, with the aid of a Gigli saw I [*] was able to fragment and remove a large branched (" stag-horn ") calculus in a single functioning kidney without encroaching upon the parenchyma. The pelvis was incised over the stone and the lips of the incision were retracted sufficiently to allow the eyed end of a probe, fashioned like an aneurysm needle, to be insinuated around the body of the stone. The stoutest silkworm gut was threaded on the probe and the probe withdrawn. A Gigli saw was then attached to the silkworm gut and carried round the stone, which was cut through easily. A second cut was similarly made and the fragments of the stone withdrawn without difficulty. Recovery was uninterrupted (Fig. 940).

Marion [†] describes a limited parenchymal incision (" Pyelotomy élargie ") continued from the pelvic incision and carried through the lip of the hilum as far as necessary to remove the stone. The retropelvic artery will probably need ligaturing. Alternative methods, when approach through the parenchyma is unavoidable, are the high-frequency knife, or division of renal tissue with silver wire or stout silkworm gut, introduced on a blunt needle. None of these methods is immune from secondary hæmorrhage.

Results of operations performed for stone in the kidney.—The operations available are pyelolithotomy, nephrolithotomy and nephrectomy, and in studying results attention is drawn, first of all, to a comparison of their relative operative mortality. Of subsequent complications we are concerned with, after the first two operations, recurrence of stone in the same or the opposite kidney, fistula formation, and, after nephrectomy, formation of stone in the remaining kidney.

At the 2nd Congress of the International Society of Urology held in 1924 were published answers to these questions from sources so widely separated that the figures announced may be reasonably accepted, especially in view of the vast numbers of cases from which they were derived.

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[*] *Proc. Roy. Soc. Med.*, March, 1935, xxix, 1127.
[†] *Traité d'Urologie*, 1935, ii, 1002.

1. **Operative mortality.**—Cifuentes, of Madrid, carried out a collective investigation upon the mortality rate of each operation. (*a*) Pyelolithotomy ; from the results of 25 surgeons there were, in aseptic cases, 18 deaths in 975 operations, a mortality of 1·83 per cent. In 178 infected cases there were 11 deaths, a mortality of 6·17 per cent. (*b*) Nephrolithotomy : from the reports of approximately the same number of surgeons, there were in 915 uninfected cases 76 deaths, a mortality of 8·3 per cent., whilst in 647 infected cases 86 died, a mortality of 10·3 per cent. (*c*) Nephrectomy showed 102 deaths in 1,265 cases, giving a mortality of 8 per cent. It is probable that the number of aseptic cases is too large for, at any rate, under the heading of nephrolithotomy Braasch contributed 188 infected cases, with a mortality of 1·06 per cent., but no uninfected cases, for he considered all cases requiring this operation were infected, the infection differing only in degree.

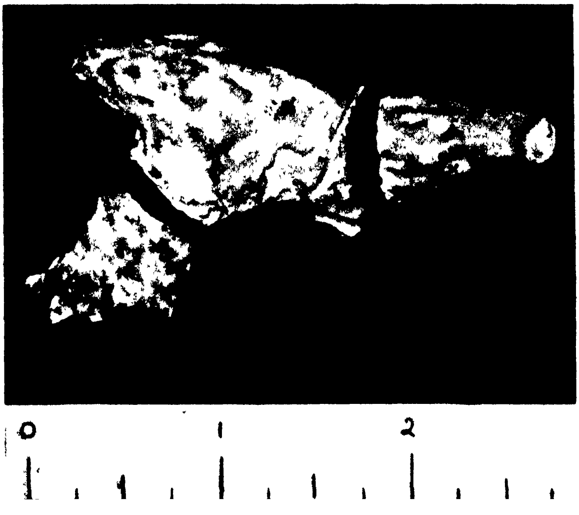

Fig. 940.—Stag-horn calculus (reconstructed) removed from a solitary kidney by the writer through a pelvic incision. The stone was trisected by a Gigli saw introduced through the pelvis ; the lines of the cuts are seen. Actual size. Weight 29 gms.

2. **Recurrence.**—The report upon recurrence of stone was considered at the same Congress by Brongersma, Amsterdam. He found that in aseptic or low grade infection the recurrence rate was practically the same (16·2 per cent.) whether nephro- or pyelolithotomy were carried out. Where marked infection was present, the recurrence rate

for either operation rose to about 50 per cent. In only one case after 50 nephrectomies for stone was there calculus formation in the opposite kidney.

Braasch and Foulds * reported results of an investigation upon 1,041 patients who had been subjected to operation for stone in the kidney through a period of 22 years, to discover the incidence of recurrence. In the 819 who were traced it was found that 371 pyelolithotomies gave a recurrence rate of 11·85 per cent., 104 nephrolithotomies of 24 per cent., whilst 327 nephrectomies showed only 2·75 per cent. stone formation in the opposite kidney. The results only include those where operation had been carried out at least 2 years before the report. It was believed that many of the so-called recurrences were stones left over from the primary operation and that the incidence would be much reduced by the wider use of fluoroscopy. The comparative rarity of opposite side stone formation suggests a predisposing anatomical factor in the affected kidney.

3. **Fistula.**—Fistula formation can be briefly dismissed, for this, formerly the bugbear of, at any rate, pyelolithotomy, is practically never seen under modern urological conditions. No case has occurred in my practice during the last 20 years ; Braasch and Foulds do not even mention it as a post-operative complication.

4. **Stricture.**—The risk of stricture at the uretero-pelvic junction has been raised as an objection to pyelolithotomy by some surgeons. It has not occurred in my practice. If the precautions outlined above are observed the risk should be negligible.

OPERATIONS FOR TEMPORARY DEVIATION OF THE URINE IN THE UPPER URINARY TRACT

Renal drainage may be required in the following circumstances :—

(i) As a preliminary to nephrectomy in infected hydronephrosis or pyonephrosis in order (*a*) to combat the mass-influence of sepsis and thereby to reduce toxæmia, and (*b*) to allow the kidney to shrink, and so render the subsequent nephrectomy less difficult and dangerous. This is also occasionally advisable in renal tuberculosis.

(ii) As a preliminary to a plastic operation for hydronephrosis, when infection already exists.

(iii) As a necessary part of the plastic operation and performed concurrently.

(iv) As a preliminary to the operation of uretero-colostomy, where the condition demanding that operation has already produced hydronephrosis and hydro-ureter with sepsis in the upper tract.

(v) In certain cases of calculous anuria, where the constitutional state forbids lithotomy, and catheterization of the ureter fails to drain the pelvis. Occasionally the stone responsible may lie within easy access and can be removed at the time of the drainage without adding to the risk. Often a stone in the ureter will pass spontaneously after nephrostomy.

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* *Trans. Amer. Assoc. Gen.-Urin. Surgeons*, 1923, xvi, 155.

(vi) In surgical trauma of the ureter, especially gynæcological operations, to preserve renal function until subsequent repair or transplantation can be carried out (*see* p. 1975).

(vii) In some cases of nephrolithotomy (*see* p. 1953).

Methods of drainage.—Although the object is to drain the renal pelvis, it is not advisable to do so by direct incision as the pelvis is less accessible and less manageable. Further, a tube introduced directly into the pelvis cannot usually be replaced. When the obstructive cause demanding the operation has been relieved, the healing of a pelvis long drained may be delayed. On the other hand, the advantages of pyelostomy are (1) its ease of performance if the pelvis is greatly distended ; (2) absence of risk of hæmorrhage. The disadvantages, however, outweigh the advantages and therefore nephrostomy is generally accepted to be the better choice.

NEPHROSTOMY

Where nephrostomy is performed as a preliminary stage of nephrectomy a small wound of approach is an advantage, making the second operation easier. An incision at right angles to the usual curved loin incision for nephrectomy will interfere less with the normal arrangement of the muscle strata, and thus will preserve landmarks which are so valuable in the subsequent nephrectomy. As drainage in these cases is somewhat crude and calls for little delicacy of technique, the small incision is adequate. The kidney is easily felt, incised and the pus evacuated. A finger is introduced and breaks down septa, and a wide straight tube, with lateral openings, is placed in the deepest part of the kidney cavity.

If kidney drainage is likely to be required for a considerable time, or possibly permanently, a more refined technique is called for, with wider exposure of the kidney. It may be necessary to dislocate the kidney from its bed and to perform the operation on the loin.

(i) **Cabot's method.**—(Fig. 941.)—A bent uterine sound is introduced through a pelvic stab and traverses a lower calyx, the kidney substance and capsule. A stout silk thread is then tied to its distal end and carried through the pelvic opening by manipulation of the sound. To the end of the silk which has been so conducted through the pelvic wound the proximal bevelled extremity of a No. 24 Ch. Malécot tube is attached and drawn through the pelvis and parenchyma, by traction on the silk, leaving the expanded end within the pelvis. After replacing the kidney and suturing the wound the tube is stitched to the skin. If there is a likelihood of nephrostomy being permanent, the tube should be stitched low down anteriorly, so that the patient may have his wound under control for changing the tube.

(ii) **Trocar-cannula method.**—The trocar-cannula outfit used for water-tight bladder drainage by the method of Kidd suffices for the

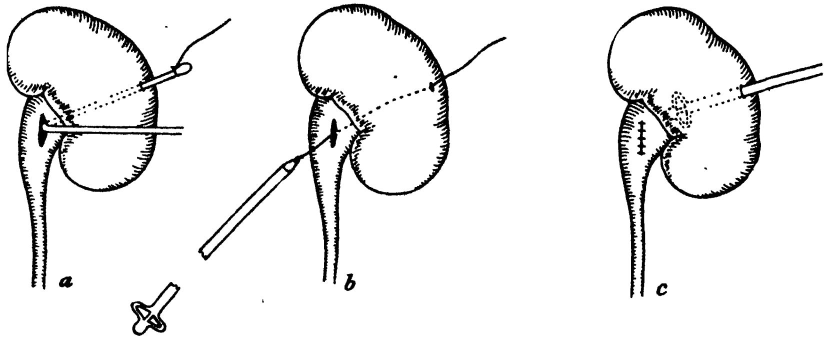

Fig. 941. Nephrostomy. Cabot's Method. Suitable in the absence of marked hydronephrosis. (*a*) A malleable probe introduced through a pyelotomy incision is coaxed through a lower calyx and penetrates the parenchyma and capsule. A strong thread is attached ; (*b*) By withdrawing the probe the thread is carried across the kidney and out of the pelvic opening. The thread is stitched to the bevelled proximal end of a Malécot tube ; (*c*) The Malécot tube has been carried up into the kidney leaving its expanded extremity within the pelvis. The pyelotomy wound is sutured.

performance of this operation, but this is not suitable unless considerable dilatation exists (*see* Fig. 942).

Marion uses a method similar to Cabot's, passing a curved clamp through a pyelotomy incision and so across the kidney through a calyx. The jaws are opened outside the capsule to receive a tube, which is thus drawn into the pelvis.

Mobilization of the kidney will probably be unnecessary in these operations.

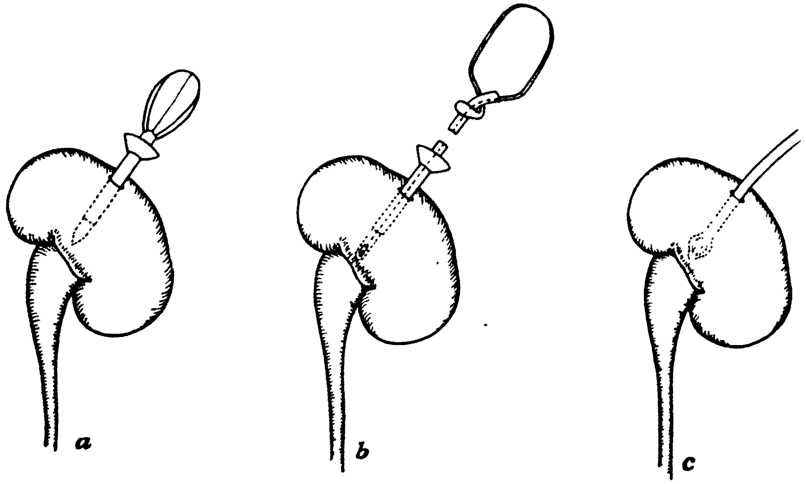

Fig. 942.—Nephrostomy by the trocar and cannula method.

The method usually adopted by the writer and suitable in the presence of marked hydronephrosis. (*a*) the trocar-cannula is plunged into the dilated pelvis ; (*b*) the trocar is removed and a Malécot tube on an introducer is passed through the cannula ; (*c*) the cannula is withdrawn over the tube leaving the tube in situ.

Note.—In practice nephrostomy should be established at a lower level than the figures indicate to avoid the 12th rib.

A tube introduced by either method may be left undisturbed for three weeks or longer, if draining properly, before changing is necessary. It may then be replaced by a similar or a straight tube, held in place by a rubber flange, which is retained in contact with the skin by a suitable belt. Water-tight drainage into a bottle can usually be maintained, and a patient may carry on tolerably comfortably in this way for months or even years if need be. Irrigation through the tube should be established early after the operation ; 1 in 10,000 silver nitrate solution is generally used, or dilute acetic acid, where the urine tends to alkalinity.

Postoperative treatment.—Where, as is commonly the case, the necessity for nephrostomy arises from causes provoking renal failure, measures must be adopted to stimulate restoration of function, as well as to inhibit the effects of uræmia and toxæmia. Glucose by the mouth, rectum and veins is valuable. Bicarbonate of soda is used if the alkali reserve is deficient, or diuresis stimulated by forced fluid intake by the mouth, rectal and intravenous salines and, amongst diuretic drugs, diuretin, theocine sodium acetate, caffeine or gin by mouth, and caffeine sodium salicylate subcutaneously (gr. 1, hourly, for 4 doses). Additionally, intravenous infusions of glucose, bicarbonate of soda and sodium sulphate (an isotonic solution) by the drip method are strongly advocated, but a careful watch must be kept that the myocardium is equal to the strain of the volume of the extra load of fluid. Œdema of the ankles and pulmonary bases, the character of the pulse, blood pressure and the nature of the respirations must be observed carefully.

Urinary antiseptics by the mouth are better avoided during the critical stages. An occasional injection of cylotropin (hexamine, sodium salicylate, and caffeine sodium salicylate) is beneficial, as this is antipyretic and diuretic, as well as a urinary antiseptic. Sulphonamides may be given where the septic element predominates, but mandelic acid only with great caution, for it damages renal epithelium and requires restriction of fluid intake, which jeopardizes the vital function of the kidney.

PLASTIC OPERATIONS ON THE UPPER END OF THE URETER AND RENAL PELVIS

These operations are required for obstruction at the upper end of the ureter and are most suitable when hydronephrosis is of the pelvic type. It is important for the success of the operations that the kidney should be free from infection, or, if bacteria are present in the urine, that the infection should be mild. Modern urinary antiseptics may procure the necessary standard but, if doubt remains, preliminary nephrostomy should be considered.

Before operating, the surgeon must know the site of the obstruction, if possible the nature of the obstruction, the extent of dilatation of the kidney, the existence of a second kidney and the functional capacity of each kidney. The presence of an obstruction and its site are investigated by an opaque ureteric catheter, pyelography and ureterography; the degree of its effects are more fully shown by excretion urography. The best method for confirming the seat of obstruction is by retrograde pyelography (with sodium iodide solution, 13.5 per cent.) where full-length passage of the opaque catheter is possible. As the catheter is withdrawn down the ureter, the opaque solution is slowly introduced by a syringe. Immediate radiography is carried out and shows a too abrupt uretero-pelvic angle or too sudden a transition from the broad to the narrow zones of the ureter. Radio-transparent stones may occasionally be identified and localized in this way, and will explain the cause of the hydronephrosis. The Trendelenburg posture may make pyelo-ureterography possible when passage of the ureteral catheter is checked. Stone is very rarely the cause of hydronephrosis requiring a plastic operation. The second kidney is investigated by all means that are employed when nephrectomy is contemplated (*see* p. 1902).

In bilateral hydronephrosis the less affected side should be operated upon first. There are four essential objects for the success of these operations: (1) removal of the obstruction; (2) reduction of the size of the renal pelvis; (3) fixation of the kidney; (4) relief of pain.

Removal of the obstruction.—Unless the shadow of a calculus or a definite kink has been demonstrated by pyelography, the cause will be discovered only at operation, so that the early steps are exploratory. The kidney is exposed by a curved lumbar incision which is carried well forwards to give ample exposure. The fascia and fat are dissected forwards in a sheet, and the lower part of the distended pelvis is demonstrated. The ureter is now exposed below the kidney and followed upwards. At this part it will usually be found normal in size and appearance.

At the lower margin of the distended pelvis the ureter may apparently disappear, where it is overlapped by the sac. If the hydronephrosis is very large and tense, it may be necessary to tap it to obtain space and to follow the ureter, but this is seldom necessary. At the uretero-pelvic junction, one of several conditions may be present as the explanation of the obstruction. The more common of these are (*a*) aberrant vessels; (*b*) adhesions binding the ureter to the renal pelvis; (*c*) narrowing of the upper end of the ureter; (*d*) misplacement of the ureter with production of a valve-like opening. It must be added, however, that in many cases no obstructive cause can be found. Such cases have been described by Von Lichtenberg and others as "functional" or "dynamic."

(*a*) **Aberrant vessels.**—A vessel or leash of aberrant renal vessels may be hidden beneath the over-lapping renal pelvis, and is exposed on raising the lower border of the sac. The ureter is angled as it passes over and behind this (Fig. 943).

The vessels as a rule pass to the lower part of the hilum. They are temporarily occluded (stretched on an untied catgut ligature) to allow the effect upon the renal vascularity to be noted. The lower pole of the kidney or a more extensive area may gradually assume a deep plum colour or fail to bleed; when incised, from interference with the circulation. The upper end of the ureter should meanwhile be examined to ascertain if a permanent narrowing is present, either as a result of or independently of the pressure of the vessels. When the surgeon has satisfied himself that temporary occlusion of the vessels has caused no vascular interference the vessels are divided and ligatured.

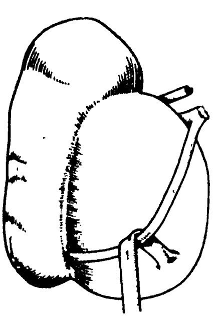

Fig. 943.—Hydronephrosis where the ureter was obstructed by the [illegible] of the renal artery.

The distended pelvis is. gently compressed by the hand, and if it empties readily the outlet of the renal pelvis is regarded as freed. Vessels responsible for pressure obstruction upon the pelvis, ureteropelvic junction, or ureter are either the posterior branch of the renal artery or, occasionally, abnormal trunks from the aorta, notably one rising one to three inches below the renal artery and passing upwards and outwards to the lower pole of the kidney. The last vessel may be as large as a ureter and strongly resemble it in appearance and position ; when present it will anchor the kidney and render delivery difficult. The extent of the distribution of any of these vessels may be so important that if division and ligature has obviously interfered with renal vascularity it may be wiser to resect the lower pole of the kidney, or to carry out nephrectomy.' Alternatively it may be better to preserve the artery and to divide and implant the ureter by the Küster or V. Lichtenberg (I or II) techniques (*see* p. 1934).

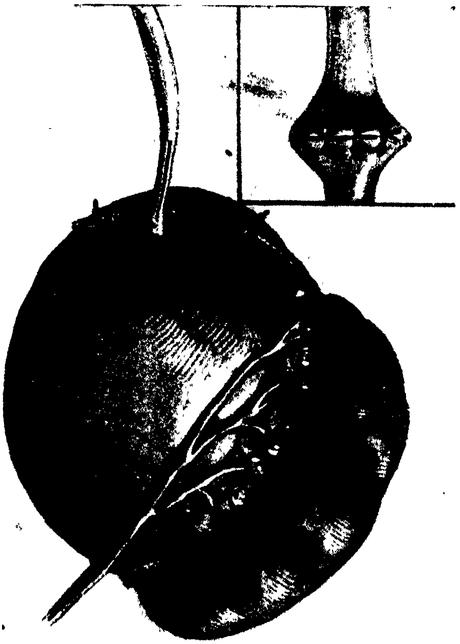

Fig. 944.—Hydronephrosis : section of aberrant vessels ; plastic operation on stenosed upper ureter.

Veins accompanying or independent of arteries may also be obstructing factors. Very frequently one of the other forms of obstruction is present in addition to the pressure of the aberrant vessels, and must be dealt with (Fig. 944).

(*b*) **Adhesions** of the upper end will be found on following up the ureter; its upper inch or so may be bound down to the face of the distended pelvis, and the narrowing of the lumen is due to kinking from these bands. The ureter should be freed from all adhesions until the point is reached where it leaves the surface of the distended pelvis. This may be at some distance above the lowest pole of the sac.

On reaching the exit of the ureter from the sac, the ureter is sometimes found drawn up into the sac like a miniature intussusception, and held in this position by a few strands of adhesions. The ureter can be drawn out of the invagination by pulling, but on releasing it the intussusception reforms. When all the adhesions are cleared, the invagination may still recur, and a plastic operation is then necessary for its correction.

(*c*) **Narrowing.**—A small segment of the upper end of the ureter or the uretero-pelvic junction may be found to be attenuated, evident both to the eye and to the touch. This condition may be present with or without a leash of aberrant vessels; a plastic operation (pyelo-ureteroplasty), is then required (Figs. 944 and 945).

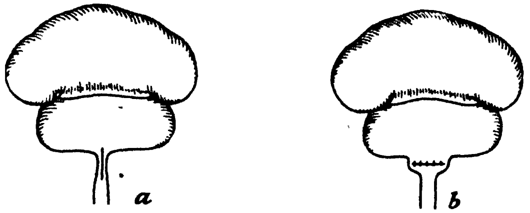

Fig. 945.—Pyelo-ureteroplasty (Fenger's operation). (*a*) **The vertical incision**; (*b*) **Transverse suturing.**

(*d*) **A valve** associated with a high placed uretero-pelvic junction.

When something more than division of aberrant vessels, adhesions or a stricture is necessary, the renal pelvis is opened by an incision in its longitudinal axis, terminating about an inch above the uretero-pelvic junction. The incision is usually made in the posterior wall of the pelvis, but in some cases the lower part of the anterior wall is easier of access and the incision is made here. The main renal vessels are on the anterior surface, but take a very oblique course upwards, and are well separated from a leash of aberrant vessels. After removing the urine from the pelvis, the lips of the wound are held apart and the interior of the pelvis examined. In the rare cases where the obstruction is due to a papilloma of the renal pelvis, this will have been suspected before opening the pelvis and will appear at the wound when the pelvis is incised. In such a case immediate nephrectomy or nephro-ureterectomy is performed.

PLASTIC OPERATIONS ON THE URETERO-PELVIC JUNCTION

Where a narrowing is found at this part, a grooved metal probe is passed into the pelvic outlet and down the ureter to define the length and calibre of the stricture.

(i) **Incision from without (pyelo-ureteroplasty).—Fenger's operation.**—(Fig. 945). The strictured section is incised for about 1 inch upon a probe, and the edges of the wound are sutured transversely with fine catgut following the principle of the operation of pyloroplasty. This operation is also suitable for the functional or dynamic type of stricture, a permanent hypertrophic contracture of the uretero-pelvic sphincter, due to a neuro-muscular dysfunction, as may be witnessed in the third stage of renal sympatheticotonus. The peculiarities of dynamic hydronephrosis have been brought to light by the more searching investigations of pyeloscopy combined with excretion urography, for which Legueu and S. H. Harris are mainly responsible. (*See* p. 1938.) An operation comparable to a Rammstedt incision for hypertrophic stenosis of the pylorus is occasionally performed, in which the incision is deepened to, but does not include the mucous membrane.

(ii) **Incision from within the pelvis. — Trendelenburg's operation.**—This may be used where the ureter is invaginated into the pelvis in the form of a valve. Instead of the narrow segment being incised from without, the lips of the incision in the pelvis are held widely apart, the spur or nipple is picked up with forceps and cut with scissors, one blade of which is in the pelvis, the other in the ureter. A valve opening is thus corrected. Fibrotic thickening of the walls of the ureter and pelvis or adhesions outside may allow division in this way without penetration of the whole thickness, but if a gap in the wall results, a few suitably-placed sutures drawing the incision together transverse to the axis of the ureter will limit it and will, at the same time, give apposition of edges and prospect of primary union with a minimum of subsequent sclerosis. This operation has been superseded by the more modern techniques; I have found it, however, to have brought a lastingly good result in three cases.

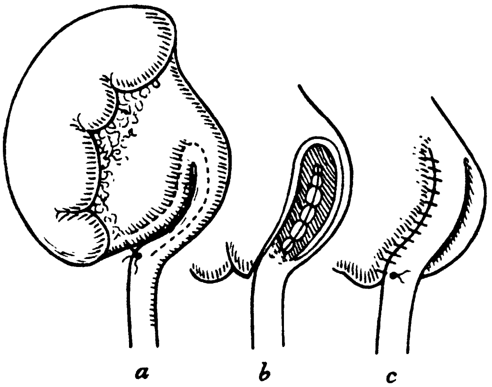

Fig. 946.—Pyelo-ureterostomy (Von Lichtenberg's No. 1 operation). (*a*) The lumen of the pelvis and ureter are opened through the dotted line; a fixation suture, below, maintains contact. (*b*) Lateral suturing approximates the deep edges, thus bringing the lumens of each structure into a common cavity; (*c*) completed when the superficial suturing is effected. This operation imitates the principles of gastro-duodenostomy.

(iii) **New orifice.**—If a faulty position of the uretero-pelvic junction defies the possibility of dependent drainage a plastic operation limited to improving the existing orifice is likely to fail to overcome the obstruction, and a new orifice must accordingly be made by some form of anastomosis at a lower level. An operation of this type may also be applicable where division of an abnormal obstructing artery of large size would possibly cause necrosis of a wide area of renal tissue;

the anastomosis may be so designed that the artery may be left undisturbed. Strictures at the outlet may also be suitably treated by these operations.

(*a*) **Von Lichtenberg's Method (Technique I).—Lateral pyelo-ureterostomy** (Fig. 946) (comparable to Finney's gastro-duodenostomy). The free part of the ureter is drawn to the lowest part of the renal pelvis and the two are sutured side-to-side. A horse-shoe incision is made into the lumens of the adjacent pelvis and ureter. The inner edges are sutured with fine catgut and then the outer edges similarly

(*b*) **Kuster's operation.**[*]—Pyelo-ureterostomy with transplantation. In this the ureter is severed from the pelvis and its open end is implanted into the lowest part of the pelvis, either by end-to-side anastomosis or laterally. This is the prototype of V. Lichtenberg's second operation (*see* p. 1936), a method which has been well tested in recent years.

(iv) **Reduction of the size of the renal pelvis.**—In spite of an operation successful in the immediate correction of obstruction at the pelvic outlet, relapse is to be expected if a lax hydronephrotic sac co-exists. There is little tendency to spontaneous involution, and it remains a large sac with a pool of retained urine which may reconstitute the obstruction by sagging over the upper ureter. As a result, the urine may eventually become infected, or a stone may form. It is necessary, therefore, to perform some operation to reduce the size of the renal pelvis as a supplement to measures for the relief of the obstruction. Three operations have been described and widely adopted ; a fourth (V. Lichtenberg II) combines this principle with excision of a misplaced or obstructive uretero-pelvic junction :—

(1) **Pyeloplication.**—Israel used this method, which resembles an operation for dilated stomach. A row of catgut sutures is introduced in the wall of the pelvis so as to fold the wall inwards in a longitudinal line. The sutures are of fine catgut and are placed by Lembert's method, commencing just above the uretero-pelvic junction and in series upwards and outwards towards the kidney. A wider hold is taken by each suture as the series goes upwards, so as to fold in a greater area. The sutures pass through the muscular wall, but do not penetrate the mucous membrane. It is recommended that the outer surface, which will be brought into contact as two sides of the fold, should be swabbed with a solution of silver nitrate or by 5 per cent. carbolic acid to promote adhesion.

(2) **Orthopædic resection (Albarran)**[†]—Albarran removed the portion of the pouch that lies below the level of the uretero-pelvic junction. This included the lower part of the pelvic sac and the lower third of the kidney. The cut surfaces are then brought together by a continuous suture. This operation is especially useful when a group

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[*] *Arch. f. Klin. Chir.*, 1892, xliv, 850.

[†] *Bull. de l'Acad. de Med.*, 1898, xl, 59.

of calculi are present in the lowest dilated calyx, a condition not uncommonly found (Fig. 947). I have had personal success with this operation.

(3) **Resection of the renal pelvis (Thomson-Walker)***—A triangular portion of the wall of the pelvis with the apex an inch from the uretero-pelvic junction and the base near the lip of the hilum is removed (Fig. 948). The posterior wall of the renal pelvis is usually resected, but in some cases the anterior wall may be more readily accessible. In the latter case the base of the triangle must be placed farther from the margin of the hilum, so as to avoid encroaching on the renal vessels. In advanced cases an area of pelvic wall should be removed from both the anterior and the posterior surfaces. The incision which has been used for emptying the renal pelvis is continued upwards and outwards towards the kidney, and another carried upwards from its outer end parallel to the margin of the hilum and about ½ in. from it. This is continued to form a flap, the extent of which will depend upon the size of the renal pelvis. The flap thus made is removed by a third incision from the apex to the base of the triangle. The edges of the wound are united with a continuous suture of fine catgut which extends to about an inch from the uretero-pelvic junction. The poles of the flabby, dilated kidney are carried forwards and inwards like horns as the suture closes the pelvic wound. The wound is now covered with a flap of the fibrous capsule of the kidney, which is turned down over it and kept in place by one

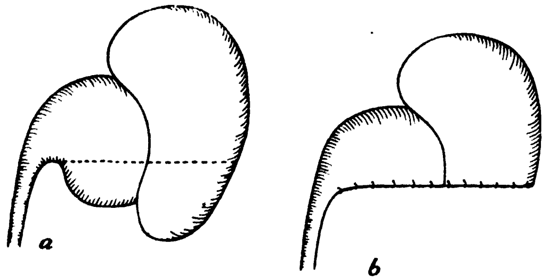

Fig. 947.—Albarran's operation (Orthopædic Resection). The pelvis is preferably divided with a scalpel, the kidney substance with the high frequency current.

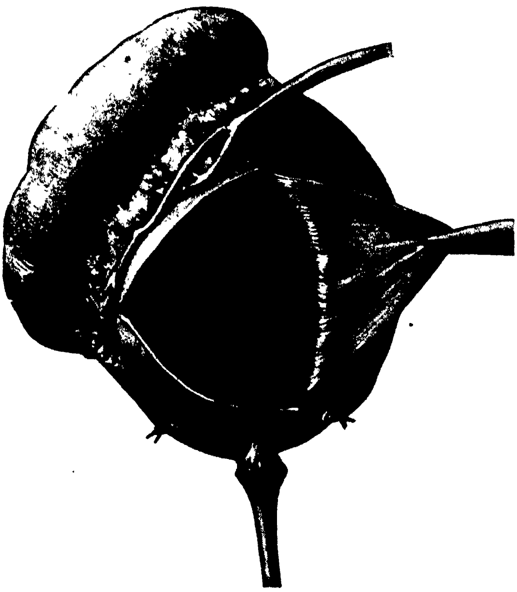

Fig. 948.—Hydronephrosis : Thomson-Walker's operation for reduction of renal pelvis.

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* *Lancet*, Aug. 11, 1906, ii, 373.

or two stitches. If a layer of peripelvic fat is available, this will form a better covering for the posterior surface, and should be used.

Before the pelvic wound is closed an incision should be made through the convex border of the kidney, and a drainage-tube passed through this into the renal pelvis, and in some cases where the plastic operation area appears to require support, a ureteral catheter should be placed alongside the drainage-tube and passed through the pelvis and down the ureter. The perirenal tissue is drained by a second tube. Drainage of the renal pelvis is maintained for a week, and the tube and catheter are then removed. The renal pelvis after the operation has a conical shape with the apex pointing towards the uretero-pelvic junction (Fig. 949 and 950).

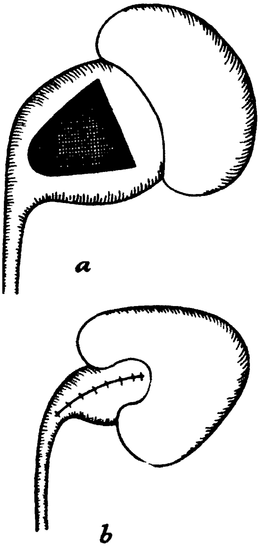

Fig. 949.—Thomson-Walker's operation. (Pelvic Resection.) (*a*) Shows area of the pelvic wall excised ; (*b*) when the pelvis is reconstructed the kidney, rendered lax by hydronephrosis, assumes a horseshoe shape.

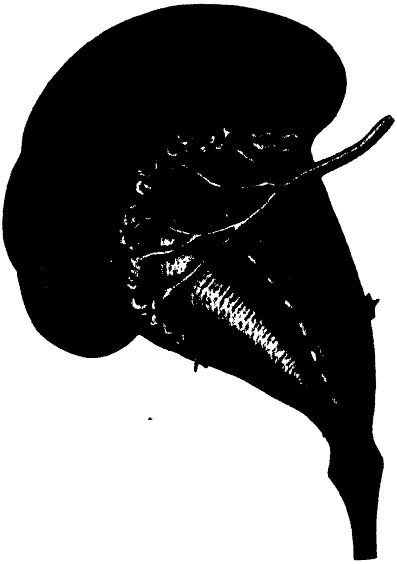

Fig. 950.—Hydronephrosis : final stage of Thomson-Walker's operation on ureter and renal pelvis, after section of aberrant vessels.

(4) **Reduction of the renal pelvis combined with removal of the uretero-pelvic junction** (Von Lichtenberg's operation II) (Fig. 951).—The upper end of the ureter is divided transversely at the point where it springs from the pelvis or below a strictured length of ureter, or valve. The pelvis is reduced by excising the anterior and posterior walls generously. A thin rubber tube is passed down the ureter for two inches and fixed with a fine catgut suture at the upper end of the ureter. Half an inch from the end of the ureter a catgut ligature is tied around the ureter which contains the tube. Holes are cut in the sides of the tube where it will be lying within the renal pelvis. Forceps

are passed through the lowest calyx from outside the capsule and these grasp the end of the tube, drawing it across the kidney substance, eventually to lie outside the superficial wound, where it will be sutured to the skin in the final stages of the operation. The edges of the pelvis are sutured in linear fashion ; the ureter, with its contained tube, taken through the inferior extremity of the line of apposition, is included in the lowest stitches. Reinforcing sutures are placed between the muscular coats of the ureter and the pelvis at the anastomosis. Additional drainage of the pelvis is secured by placing a larger (nephrostomy) tube alongside the smaller one through the same calyx. A third tube or rubber strip is employed for perinephric drainage. The ureter and nephrostomy tubes are removed in 10–14 days, the perinephric drain on the 5th day.

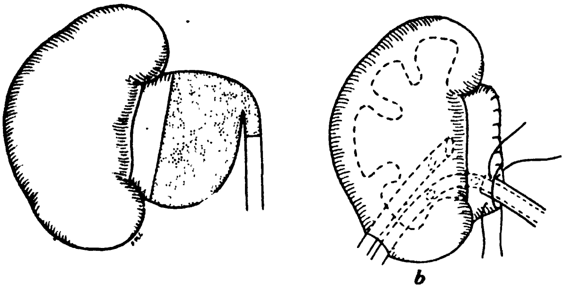

Fig. 951.—Von Lichtenberg's operation for hydronephrosis by excision and implantation (No. II operation.) (*a*) Condition before operation ; the stippled area will be excised ; (*b*) the pelvic stump is sutured leaving space in the lowest part to transmit the ureter, supported on its tube and picked up by the lowest stitches at its entry. The nephrostomy and ureter tubes are carried through the lowest calyx (after Victor Dix, Maingot's Postgraduate Surgery, Vol. II. By courtesy of Medical Publications, Ltd.)

Von Lichtenberg * reports 80 operations for renal obstruction. In 41 per cent. primary nephrectomy was required and in 59 per cent. a conservative operation could be employed. In 27 per cent. the obstruction was considered to be neurogenic.

Fixation of the kidney.—Nephropexy is a necessary supplement to many operations designed to correct a mechanical defect. Unless the kidney and ureter are fixed in such a way as to assist drainage by preventing the drags or kinks of faulty alignment or undue mobility, plastic operations cannot be permanently successful.

Relief of Pain.—Fortunately this appears to be constant, though not always lasting, whichever operation is performed. This has led to the belief that it is the outcome of sympathetic nerve division in freeing the kidney (*see* p. 1940).

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* *Ann Surg.*, Nov. 1935, cii, 849–862.

DANGERS AND SEQUELÆ OF RADICAL OPERATIONS FOR HYDRONEPHROSIS

1. **Hæmorrhage.**—There is a danger of hæmorrhage into the hydronephrotic sac after the operation. This may occur during the first two days, or as late as a week after the operation. No large vessels are cut in the wall of the hydronephrosis, and a possible source of the hæmorrhage is necrosis of the kidney from vascular interference. Late hæmorrhage may also be due to the pressure of one of the drainage tubes causing erosion of a vessel. Severe hæmorrhage should be met by opening up the wound in the kidney and either packing it or removing the kidney. Blood transfusion is of great value as a hæmostatic agent, as well as to replace blood lost.

2. **Sepsis.**—Occasionally sepsis may extend into the renal substance with formation of a cortical abscess. Urine may extravasate through a path so established, as well as through failure of primary union in the pelvic suture line. Re-establishment of nephrostomy may be successful, but nephrectomy is likely to be required later owing to persistence of the sepsis, especially if aberrant vessels were divided at the primary operation.

3. **Fistula.**—This may result from failure to re-establish the lumen of the pelvic outlet, or it may be due to sepsis. Whatever the cause, an attempt should be made to pass a ureteric catheter and, if successful, to retain it *in situ* for a week. If this fails, another operative attempt may be made to establish the lumen, but this should be deferred for some weeks ; if unsuccessful, nephrectomy will be necessary.

4. **Widespread necrosis of the kidney from vascular interference.**— —In a case of my own, a very stout female, there was pyrexia about the 10th day and a deep-seated mass could be felt. Pus pointed in three areas of the incision but the mass remained, sinuses continued to discharge pus, but no urine. Intravenous pyelography showed no excretory function in the third week. Exploration then revealed a shrunken necrotic kidney, riddled with abscesses, in which no normal excreting substance remained. Recovery after nephrectomy was uneventful. In this case, one of first degree hydronephrosis and duplication of the ureters compressed by an aberrant vessel, a quite small vessel had been ligatured. Had it not been for the arrest of functional activity the chain of symptoms might have given reason to fear an indwelling swab !

RENAL DENERVATION (SYMPATHECTOMY)

This operation, originally introduced to procure relief from renal pain where no inflammatory or anatomical explanation was available, has been widely adopted since S. Harry Harris described the symptom-complex which he named " renal sympatheticotonus." This, an obstructive nephropathy, exhibiting the three stages of (i) irritability, or systole ; (ii) exhaustion, or diastole, and (iii) paralysis or hydronephrosis, he presumed to be due to over-activity of the sympathetic nerve supply to the kidney. Recurrence after temporary relief by injections of eserine (gr. 1/60) and the absence of any demonstrable cause of organic obstruction are significant and, with the rest of the clinical picture, indicate the operation.* Harris modified slightly the original technique of E. Papin † in the method of denuding the renal vessels; the kidney is exposed from the loin, completely separated and delivered, exposing the vascular pedicle, the hilum and the upper end of the ureter. Papin's method of gauze dissection of the vessels in a mesial direction hazards the tearing of veins, a risk overcome in the Harris modification by elevating the pedicle on the index finger and carrying out instrumental dissection from within outwards, commencing as far from the kidney as possible. The vessels are denuded in turn, and finally the renal pelvis, the uretero-pelvic junction and the first inch of the ureter. The application of 10 per cent. carbolic acid to these structures may show up and destroy any overlooked fibrils. Harris claimed good results of this operation with cautious case-selection, and his claims have been substantiated by the subsequent experience of Wells, Riches, Oldham, Underwood and others in this country, their results having been proved by pyelographic reviews.

RESULTS OF CONSERVATIVE OPERATIONS FOR HYDRONEPHROSIS

In an organ such as the kidney, where the possibility of anatomical restoration is meagre, the ideal of procuring a permanent state approaching the normal is seldom realized, and the surgeon must content himself with relative rather than absolute perfection. A far higher standard is aimed at to-day than hitherto, when relief of pain sufficed as a measure of cure. E. W. Riches, summarizing the criteria of success, adds to the clinical or symptomatic result the need of study from the radiological, functional and bacteriological viewpoints. Without a universal acceptance of so high a standard, analyses of reported results cannot render a statistical review convincing. The following impressions, however, are gathered from a study of available records of the results of the four operative categories:—

(i) **Division of vessels.**—Pain is invariably relieved, but dilatations remain and may require supplementary plastic surgery.

(ii) **Minor plastic procedures** of the pyelo-ureteroplasty (Fenger or Foley Y-plasty) type appear to give good results in 75 per cent. of cases.

(iii) **Major plastic operations.**—Where the pelvis is drastically resected with re-implantation of the ureter a wide divergence of results is apparent. As in many cases such operation offers the only alternative to nephrectomy and "if the radical removal of the obstructing cause is not practicable,‡ a considerable proportion of failures is to be expected." Thus Walters, Cabot and Priestley[*] found benefit in under 50 per cent., and secondary nephrectomy was necessary in 21 per cent. of their cases. In Von Lichtenberg's series of 47 cases nephrectomy was necessary in 7 per cent. More recently E. W. Riches and Hamilton Bailey[†] reported two series of 31 and 26 cases respectively with good results in 61 and 54 per cent., but others of the British school have been less fortunate.

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* *Proc. Roy. Soc. Med.*, 1935, xxviii, 1497.
† *Journ. Urol.*, 1924, xi, 337.
‡ Von Lichtenberg, *Journ. Amer. Med. Assoc.*, 1929, xciii 1706.

(iv) **Sympathectomy.**—Reporting on a series of 28 results where the operation was performed for the relief of renal pain J. B. Oldham[‡] observed that the relief of renal pain was practically universal. At the same time pyelographic evidence proved anatomical and functional improvement. E. W. Riches, in a series of 13 cases, was able to demonstrate the same benefits, and in certain hitherto intractable cases of hydronephrosis with infection postoperative sterilization was achieved.

THE OPERATIVE TREATMENT OF INJURIES OF THE KIDNEY

Before deciding to operate consideration must be given to the following questions :—

(*a*) Is bleeding arrested, or progressive to the extent of endangering life ? Increasing pallor, pulse rate, restlessness and a suggestive blood picture should be noted.

(*b*) Does the constitutional state demand or warrant immediate exploration or is it not wiser to give pre-operative intravenous infusions of saline, gum acacia or a blood transfusion ? A blood transfusion is essential where hæmoglobin is under 60 per cent.

(*c*) Are there associated abdominal or thoracic injuries requiring exploration ?

(*d*) Is there a perinephric hæmatoma which is likely to suppurate or which already shows signs of suppuration ?

(*e*) Is the damage to the kidney probably so severe (*a*) that it is unlikely to function efficiently as an excretory organ or (*b*) that by scar tissue formation the major conducting channels will be so distorted that a painful hydronephrosis is likely to follow ? Intravenous and retrograde pyelography will supply available information ; the former will indicate the state of the opposite kidney and hence is useful in the early stages. Retrograde pyelography is only required to determine the existence of hydronephrosis as a later sequela ; its early use would add an unwarranted risk.

Such operations as are performed will follow the general principles of renal surgery. The method of approach will depend upon whether the kidney alone is affected, in which case the usual lumbar incision is made, or whether associated grave injuries indicate laparotomy with, if necessary, transperitoneal, or anterior extra-peritoneal nephrectomy or renal repair.

[*] *Journ. Urol.*, 1938, xxxviii, 688.

[†] *Proc. Roy. Soc. Med.*, 1939, xxii, 1657.

[‡] *Liverpool Med-Chir. Journ.*, 1936, xliv, 81.

Technique.—When exploring the kidney by the lumbar route extravasated blood and, possibly, urine will be encountered as the muscles are divided. A large perinephric hæmatoma does not necessarily indicate a gross renal tear. Blood clot and blood-impregnated fat are removed and the kidney is freed, delivering it upon or as near to the surface as possible. Circumscribed splits or tears are sutured with mattress or figure-of-eight stitches, but objection has been raised to the amount of renal destruction caused by such hæmostatic sutures. Albarran placed a network of catgut sutures around the kidney to hold the fragments together (cerclage du rein). In this method four stout catgut sutures, two above and two below the pedicle, embrace the kidney and are placed partly extra- and partly sub-capsularly ; Lowsley has adopted a similar principle, using ribbon catgut. When the capsule is intact, contusion is at a minimum and there is little perinephric hæmatoma ; mattress sutures hold well and stop bleeding, but under less favourable circumstances they cut into the kidney substance and are useless ; buffer pads of fat or muscle may then be placed under the loops of the stitches and provide a firmer hold, or the same object may be achieved by placing catgut sutures parallel with the edges of the wound to be closed and embracing these in the loops of straight sutures (Fig. 928). If a section of kidney, for instance one or other pole, is extensively damaged, it should be removed and the adjacent surfaces sutured after the interposition of a pad of fat or muscle in the manner described under excision of a serous cyst (p. 1909).

Comminution or pulping calls for nephrectomy if the general state warrants it ; otherwise tight gauze packing is used as a temporary step, especially in stabs or gun-shot wounds. Established sepsis will generally require nephrectomy. Continuous intravenous saline and glucose drip infusion, or blood transfusion, may be life-saving measures.

In contrast with injuries to the bladder and urethra, a policy of procrastination in deciding the time of operation may be adopted with advantage ; extravasation of urine is seldom to be feared, for the pelvis and calyces are seldom grossly injured and, moreover, a kidney so severely damaged ceases to excrete long enough for the appearance of other physical signs, which would give definite indications for or against operation.

Hæmaturia from a ruptured kidney may be severe enough to give clot retention in the bladder in about 8 per cent. of cases. Bigelow's evacuator and the intied catheter will overcome this difficulty.

Certain late results of renal injuries may require operation. Amongst these are stone formation, chronic sepsis and hydronephrosis. Hydronephrosis is usually of the renal type and is caused by distortion of the calyces from fibrous tissue formation. Attention is drawn to the condition by intractable pain, and nephrectomy will then be required.

Causes predisposing to rupture.—Developmental defects and disease render the kidney susceptible to rupture even as the result of a mild trauma. Of the diseases, hydro- and pyonephrosis, tuberculosis, lithiasis and polycystic disease are recognized. The horseshoe kidney furnishes the best example of a developmental cause, its exposed position, fixation, and fragile parenchyma stretched over dilated calyces accounts for this tendency. Three cases in my practice were mild and the tears were easily repaired by mattress suturing. More severe injuries may require heminephrectomy.

OPERATIONS ON ANOMALOUS KIDNEYS

The cystoscopic demonstration of ureteric orifices of normal appearance, situation and excreting power does not necessarily indicate normal kidneys ; malformation may exist, such as solitary, horseshoe or a unilateral fused kidney. Pyelography provides the proof. More attention is now directed to these abnormalities than formerly, on account of the ever-increasing clinical recognition of upper tract pathology by excretion urography and its wider admission to the scope of surgery. Eccentricities of the ureteric orifices, such as multiplicity and abnormality of situation, are recognized cystoscopically, urethroscopically, and on vaginal examination.

(*a*) **Horseshoe kidney.**—Operation may be required for (1) *pain* due to tension within the isthmus, or to pressure of it upon adjacent nerves ; (2) *hydronephrosis* from obstruction of the ureter by the isthmus ; heminephrectomy is required if hydronephrosis of one kidney is too advanced for conservation ; (3) *calculi* in the pelvis or calyces. Pyelolithotomy, unless the patient is unduly stout, generally presents no difficulty, for the anteriorly placed pelvis is usually approached with ease and, since the pelvis is commonly dilated, manipulations and suturing are readily effected. It must be noted, however, that the isthmus does not obstruct the ureter, otherwise a permanent fistula may result. Whenever possible the isthmus should be divided (symphysiotomy) to remove tension and pressure upon the ureter and nerves, as well as to allow nephropexy in a position whereby easy drainage from the pelvis is assured, and to establish an uninterrupted course for the ureter. In the division of the isthmus double clamps are applied an inch apart and the intervening tissue is divided with the high frequency knife (Fig. 952). Hæmostasis is further insured by including the whole width of the isthmus in mattress sutures, which are placed in position lateral to each clamp and tied as the clamps are removed. Nephrolithotomy, unless symphysiotomy can be carried out, is both difficult and dangerous, as the anchoring of the kidney by the isthmus prevents sufficient mobilization for its vascular supply to be kept under complete control during incision into the renal substance. After symphysiotomy nephropexy is a necessary step to preserve a direct course of the ureter (Fig. 953). (4) *Injuries* (*see* p. 1940). (5) *Tuberculous disease and new growth.* Large numbers of instances of heminephrectomy have been reported for both these conditions ; among the growths squamous-celled and adenocarcino-

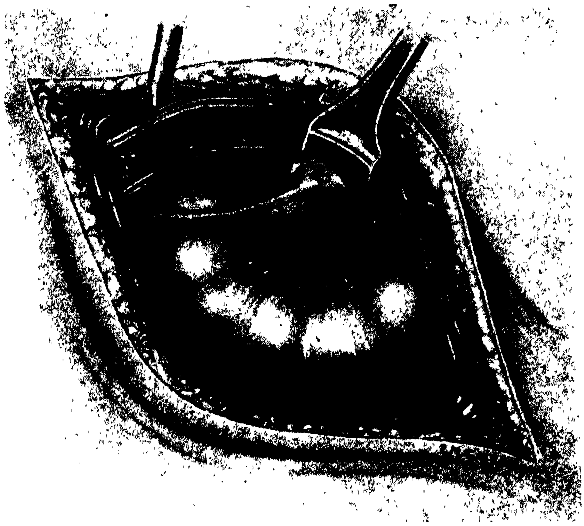

Fig. 952.—Horseshoe Kidney. The ureter is retracted over the left kidney while division of the isthmus with the high frequency current is in progress. Pyelolithotomy was also performed in this case.

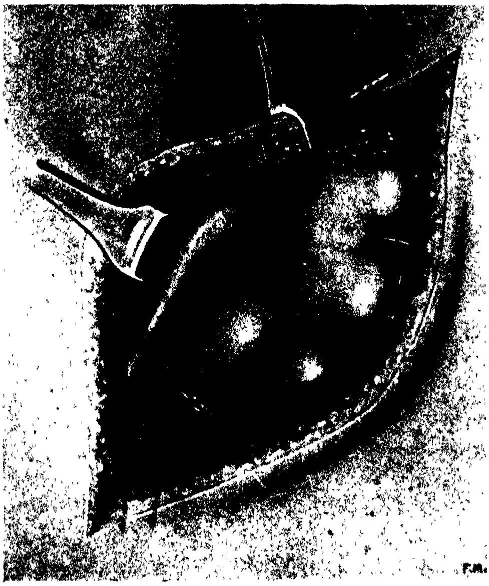

Fig. 953.—Horseshoe Kidney (drawn from the same operation as shown in Fig. 952).

To show the final stage; nephropexy after symphysiotomy. A stone was removed from the pelvis and the suture line is seen (transverse). The knots of the hæmostatic sutures on the isthmus and the fixation sutures to suspend the kidney are shown. The last rib is retracted to give better exposure, and the position of the drainage tube, which lies on the anterior surface of the kidney is indicated.

mata, as well as the more common cortical and pelvic neoplasms, appear in the records.

(*b*) **Ectopic kidneys.**—Pain and a mistaken diagnosis are the common reasons for operation. Many years ago I explored an abdomen for a circumscribed tender swelling the size of a golf-ball low in the right iliac fossa, expecting to find a chronic appendix abscess; an atrophic ectopic kidney exhibiting pyelitis was removed. Ectopic kidneys, being developmental defects, differ from ptosed kidneys in the irregularity of their vascular supply, and this feature gives their surgery added technical difficulties, especially where the organ is deeply placed in the pelvis. The greatest care must be exercised to clamp all the supplying vessels, including those, possibly, from the opposite iliac vessels, before removal, and in so doing to see that the opposite ureter is protected. Transperitoneal nephrectomy is more usually adopted.

(*c*) **Crossed dystrophy** (einseitiger Languiere of Rumpel), in which the fused mass of total kidney substance is to one side of the mid-line: one element may be the seat of hydronephrosis, infection or calculus formation. Rumpel successfully resected a lower element pyonephrosis through a mid-line transperitoneal approach.

(*d*) **Renal and ureteric duplications** are common abnormalities. Any grade may be found from a complete development of two ureters in their entirety—and in this case the surface of the kidney may show a transverse groove representing the line of division—to merely a low division of the pelvis. When the two ureters exist in their whole lengths the orifice of one may encroach upon the vesical sphincter or be urethrally placed in either sex, giving rise to incontinence. Reduplication of ureters of full length leads to inevitable crossing which takes place usually at, or near, the pelvic brim. One tube bears the brunt of mutual pressure more than the other and the kidney element of the more affected ureter becomes hydronephrotic, possibly pyonephrotic, and atrophic. A similar change, however, may be found in one kidney element when the duplication of the ureters is short and there is no crossing, for no very apparent reason. Finally, an aberrant renal vessel is often found to cross and obstruct duplicated ureters, causing pain, with or without hydronephrosis.

Many of these complications will require surgical treatment; modern urological surgery has advanced beyond the stage of mere nephrectomy. Heminephrectomy is the operation of choice where one renal element is hydro- or pyonephrotic, separation through the parenchyma—endeavouring to follow the natural boundary indicated by the superficial groove—being effected by the endothermy current. The ureter should be removed when it is greatly dilated. In the rarer types, where the accessory ureter meatus is in or below the bladder sphincter, transplantation to the bladder may be performed after proving the integrity of that part of the kidney which it drains.

(*e*) **The atrophic painful kidney.**—This is a rare condition, the ætiology of which is obscure. Three examples, all in females, have been treated by nephrectomy in my practice, with complete relief of pain. Each was diagnosed by retrograde pyelography and appeared as a hydronephrotic sac. In two, the kidney, little larger than a greengage, was difficult to find.

(*f*) **Solitary kidney.**—A ureteric orifice, more or less normal in appearance and position, may be seen on the side of the non-existent kidney. Passage of an opaque catheter and the introduction of a radio-opaque fluid through it may show a blind cul-de-sac, merely a vesical diverticulum, the remnant of an effete ureteric upgrowth.

THE OPERATIVE TREATMENT OF POLYCYSTIC DISEASE OF THE KIDNEYS

This disease is now generally accepted to be bilateral, hence those surgeons who formerly advocated nephrectomy in what they presumed to be unilateral examples were unaware of the true pathology. The only operation which offers prospects of benefit is that of multiple cyst puncture recommended by Rovsing. * The main object of this manœuvre is to prolong the life of surviving renal tissue by removing the pressure of as many cysts as possible. Occasionally, where acute symptoms have arisen, suppuration will be found to have taken place within the cysts, and then there is no alternative to drainage. In one case of this nature I explored an obviously inflammatory mass in the loin expecting to find a perinephric abscess. A suppurating polycystic kidney was found and as many cysts as possible were opened. The patient, a young man of 19, made a good immediate recovery, but was subsequently lost sight of.

In addition to Rovsing's operation, on patients in whom efficiency tests have proved depressed renal function, I have also found it necessary to operate to relieve cardiac and respiratory embarrassment caused by pressure upon the diaphragm from the great size of the cystic kidneys. After exposing the kidneys, as many of the cysts as possible may be rapidly and bloodlessly punctured with the endothermy current. On account of the risk of renal failure in advanced cases it is wiser to allow an interval before operation upon the second kidney.

THE OPERATIVE TREATMENT OF PERINEPHRIC ABSCESS

A variety of abscesses are included under this heading :

(*a*) Those extending into the perinephric fat from cortical necrosis caused by an infected focus in the kidney, such as (i) suppuration associated with a calculus ; the stone may find its way through the necrotic zone into the abscess within the perinephric fatty envelope ; (ii) a renal carbuncle ; (iii) a septic infarct ; (iv) renal trauma.

(*b*) Extension from an adjacent septic process ; (i) intraperitoneal suppuration such as an abscess from appendicitis, diverticulitis, cholecystitis, carcinoma coli, or a localized retroperitoneal perforation of the duodenum; (ii) suppurative lymphadenitis; (iii) vertebral osteomyelitis, coccal or tuberculous; (iv) an empyema.

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* *Hospitalstidende*, Feb., 1911, p. 105.

(*c*) Blood-borne infection, from a distant septic focus, especially a staphylococcal cutaneous lesion.

(*d*) Lymphatic spread, e.g. from a prostatic abscess.

(*e*) A suppurating hæmatoma.

(*f*) An abscess arising from urinary extravasation.

Although " perirenal suppuration " might more accurately describe abscess formation within the perinephric fascia and the term " pararenal " be applied to suppuration outside the fatty envelope, it is customary in this country to avoid this anatomical differentiation. These abscesses may be uni- or multilocular. It is seldom wise to attempt more than the establishment of thorough drainage, for which an oblique lumbar incision of about 4 inches is primarily made; the incision is lengthened according to the requirements of the areas to be drained. After traversing the muscular strata and transversalis fascia, pus is usually encountered. A finger passed into the cavity will generally break down septa and, in this way, all loculi should be freely opened up, revealing at times a wide district of infection, perhaps extending under the diaphragm, or tracking downwards to the pelvic brim or even below it. In the course of digital exploration an obvious track into the kidney may be recognized, with, perhaps, a stone in its depth. The stone should be removed, usually a matter of no great difficulty, but it is not advisable to look for stones unless their large radiographic shadows indicate an easy discovery. It is seldom wise to pursue a primary operation further. Thorough drainage is established by tubes or strips of corrugated rubber, some of which may drain the depth of an intrarenal pus cavity. Any deliberate operation directed to the kidney which may be necessary is better deferred until acute local sepsis has subsided and constitutional improvement is established.

OPERATIONS UPON THE URETER

Incisions for exposure.—The lumbo-ilio-inguinal incision of Morris, Israel and Albarran, if carried to the margin of the rectus muscle, will permit approach but not surgical access, to the whole length of the ureter. For a localized operation upon any section except the juxtavesical an incision in this line will satisfy the requirements, but the unavoidably extensive division of nerves and muscle fibres, risking hernia formation, precludes its use for complete ureterectomy. A vertical sub-umbilical mid-line or paramedian incision is preferable for exposure of any part of the pelvic ureter, not only for the customary extraperitoneal approach, but also, occasionally, where it is desirable to adopt a transperitoneal route. In the latter case a rectus-splitting incision is preferable, and this is the approach most generally adopted for ureter transplantation to the bowel, *see* p. 1966. The various incisions for exposure of the lower abdominal and pelvic ureter are shown in Fig. 954, which also includes transperitoneal routes.

The routine methods for exploring the lumbar, iliac or pelvic sections of the ureter extraperitoneally are :—

1. **The lumbar approach.**—A 4-inch incision is made from a point ½ inch below the last rib at the outer margin of the erector spinæ downwards and forwards through all the muscles, lumbar aponeurosis and transversalis fascia in its line. If it is not necessary to explore it, the kidney can be pushed upwards with its fibro-fatty investments undisturbed. The ureter is found lying on the psoas muscle behind the ascending colon or cæcum on the right and descending colon and sigmoid on the left side. The ureter in this part of its course is not adherent to peritoneum or to the extraperitoneal surface of the bowel, and lies on the posterior abdominal wall, when the bowel and peritoneum are stripped forward. To aid the search it may be made tense by pushing the lower pole of the kidney well up and under the ribs. It can often be identified by the characteristic vermicular movements, which may be elicited by gentle mechanical stimulation. Surrounding the ureter are a number of veins and in close relation to it is the spermatic or ovarian vein ; incautious handling may therefore result in troublesome bleeding.

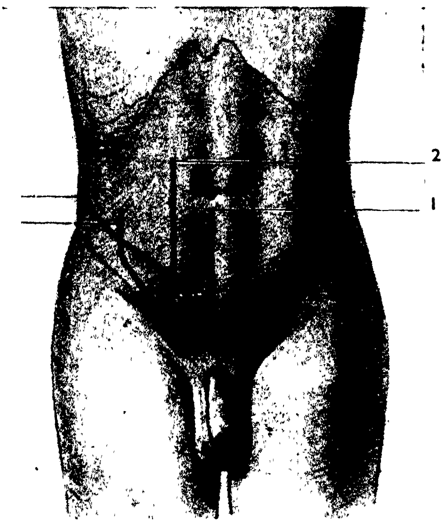

Fig. 954.—Incisions for exposure of ureter.

1, Median incision for extra- or intraperitoneal exposure of pelvic segment. 2, Paramedian incision for extra- or intraperitoneal exposure of lumbar and pelvic segments. 3, Lumbo-iliac incision for extraperitoneal exposure of lumbar segment. 4, Curved inguinal incision for extra-peritoneal exposure at brim of pelvis.

If the operation requires full exposure of the kidney and pelvis, it will be necessary to open enveloping fascia and fat the fibrofatty sheath which is closely attached to the pelvis posteriorly. This opening-up should not be done without due consideration, for the prospect of a future operation must be borne in mind, especially in calculus disease. A subsequent operation upon the kidney would be all the more difficult on account of dense adhesions if the perinephric fascia and fat had been needlessly disturbed.

2. **The iliac approach for exposure of the lower abdominal ureter.**——Here the incision begins an inch above and external to the anterior superior iliac spine, or higher and more mesial if necessary, and passes down and in to an inch above the mid-Poupart point. Muscles are partly incised and partly split. The peritoneum of the iliac fossa is elevated, and this is aided by a partial Trendelenburg posture. The external iliac artery is traced back to the bifurcation of the common

iliac, at which position the ureter is seen and felt. If it is necessary to expose the ureter at a somewhat higher level the incision is lengthened upward and, in this case, the peritoneum can be retracted more easily if the buttock of the same side is elevated on a sandbag. The higher the field required the more will the patient be rotated to a position corresponding to that adopted for operations on the kidney. In establishing drainage at the completion of this operation it is essential to avoid placing a rigid tube in contact with the iliac vessels whose course it would cross as it passes to the ureter. Hæmorrhage has arisen from erosion of the vessel walls by pressure of an unyielding tube; corrugated rubber tissue, being resilient, is free from this danger.

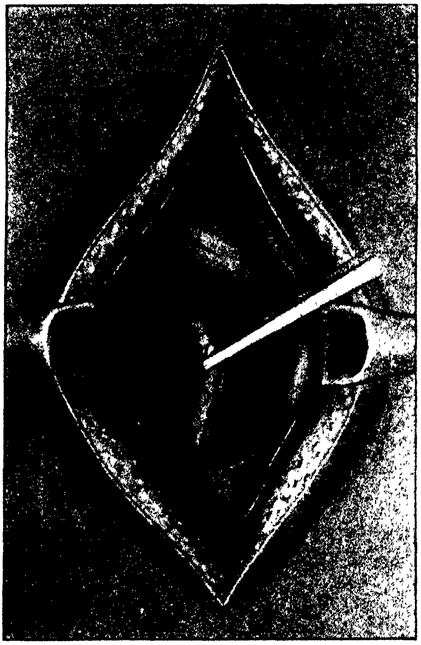

Fig. 955.—Extraperitoneal exposure of the whole length of the pelvic ureter through the median sub-umbilical incision.

Note the dilated ureter crossed by the vas; the superior vesical artery has been divided to allow forward and lateral dislocation of the posterior surface of the bladder.

The rectus incision.—This is an alternative to the iliac. A vertical incision is made ¾ inch mesial to the linea semilunaris, as long as is necessary. The anterior layer of the rectus sheath is divided and the muscle is split or retracted. The transversalis fascia is incised to the full length of the wound and the plane of cleavage between it and the peritoneum opened up. The peritoneum is fully separated from the abdominal wall and displaced upwards and mesially without being opened. The ureter may, by adjusting the length of the incision, be explored from the kidney to as low in the pelvis as need be. The operation is suitable in thin patients, but it does not give such good exposure to the abdominal course of the ureter as do the other methods. It may leave a weak abdominal wall.

3. **Median sub-umbilical incision.**—This, made from the pubic symphysis to the umbilicus in the mid-line, gives the most direct exposure of the pelvic ureter* (Fig. 955).

Technique.—The linea alba and transversalis fascia are incised and the extraperitoneal fat exposed. The patient is placed in the Trendelenburg position, and the peritoneum is fully stripped from the iliac fossa and the lateral pelvic wall on the side of the ureteric lesion. This stripping should be commenced over the bladder, and is then carried on across the external wall of the pelvis. The external iliac vessels are exposed, and the peritoneum stripped inwards from the iliac fossa, laying bare the common iliac vessels and the lower part of the muscles of the posterior abdominal wall. Alternatively, the displacement of the peritoneum may be begun in the iliac fossa, the common iliac vessels exposed, and the stripping continued into the pelvis, following the line of the ureter downwards. Self-retaining abdominal retractors and good illumination are essential for this part of the operation. By this route the lower part of both ureters can be readily exposed simultaneously.

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* J. Swift Joly, *Lancet*, 1913, i, 1092.

Difficulties and dangers.—Certain difficulties may be encountered during this part of the operation. Injury to the peritoneum may be produced in incautious stripping, or by the sharp edge of a retractor. The rent should be closed by a continuous catgut suture. In the female subject, the broad and round ligaments prevent the free stripping of the peritoneum from below upwards. It is better, therefore, in women, to strip the peritoneum from the iliac fossa first, and to follow the ureter downwards, tracking it carefully beneath the base of the broad ligament and taking pains to avoid the numerous vessels (Fig. 956). In the male the displacement may begin at the bladder or at the brim of the pelvis. In either case the vas deferens, with its accompanying vessels, stretching across from the wall of the pelvis to the bladder, limits the exposure of the pelvic floor. The vas is isolated, and the ureter may be exposed above or below it (Fig. 957).

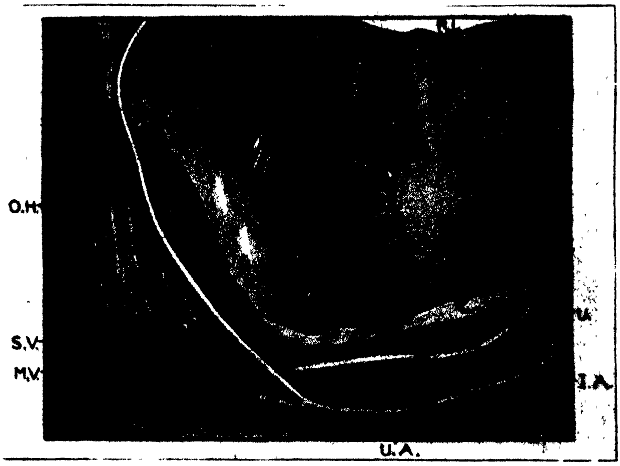

Fig. 956.—Relations of the lower end of the left ureter in the female.

The lateral aspect of the pelvic peritoneal sac is seen. *Drawn from Specimen 296, Room 2, Hunterian Collection, by permission of the Royal College of Surgeons.*
U, ureter. IA, internal iliac artery. UA, uterine artery. OH, obliterated hypogastric artery. SV and MV, superior and middle vesical arteries. RL, round ligament.

If a hernia is present, the peritoneum is adherent round the internal abdominal ring, and this interferes with the full exposure of the lower segment of the ureter, but the sac can usually be easily separated and drawn into the abdomen, thus freeing the peritoneum. Previous appendicitis, operations on the female pelvic viscera, pelvic cellulitis, the massive scar tissue round a ureteral fistula, all interfere with the stripping of the peritoneum and may necessitate opening the peritoneum and performing the operation partly as an extra- and partly as an intraperitoneal procedure.

Hæmorrhage may cause difficulty. In a straightforward case it is due to want of care in preparing the ureter and avoiding the internal iliac vein and its tributaries. With a deep wound in a stout subject, especially a multipara, venous hæmorrhage may cause a good deal of trouble. Free exposure and a good light are essential for controlling the bleeding.

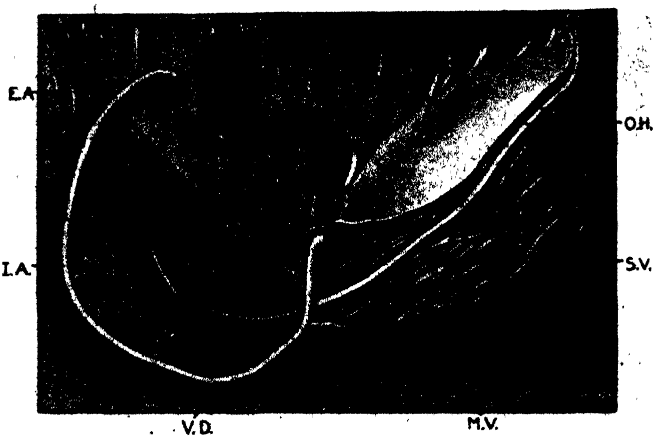

Fig. 957.—Relations of the lower end of the right ureter in the male.

Drawn from Specimen 291, Room 2, Hunterian Collection, by permission of the Royal College of Surgeons.

U, ureter. EA, and IA, external and internal iliac arteries. VD, vas deferens (divided). SV and MV, superior and middle vesical arteries. OH, obliterated hypogastric artery.
(Figs. 955-957 are reproduced from the Proceedings of the Royal Society of Medicine, xxxv, 295, Sect. Urol. I, by permission of the Honorary Editors).

Difficulty in finding the ureter may cause delay in the operation. The ureter, when supple and neither thickened by inflammation nor dilated, adheres to the peritoneum in the pelvis and may be displaced with it and overlooked. When the ureteral wall is thick there is no difficulty in finding it. From its unexpected size (megalo-ureter) it may not at first be recognized as a dilated ureter. If any difficulty is encountered, search should be made at the bifurcation of the common iliac vessels, over which the ureter passes into the pelvis, and to which the wall is sometimes firmly adherent. In the deeper part of the pelvis some doubt may be felt in deciding at what depth the ureter lies. Here the spine of the ischium should form the guide, the ureter crossing the tip of this and lying directly upon it, or the vas may be traced downwards and will lead the surgeon to it. The passage of a catheter or a bougie up the ureter by cystoscope before commencing the operation is often of service.

A drainage-tube or rubber tissue is placed near an incision in the ureter or, if the ureter has been removed, down to the pelvic floor. The abdominal wound is closed in layers. The drain should be retained for five days.

Alternative methods of approaching the pelvic ureter are given on p. 1954.

Transperitoneal exposure of the ureter.—This approach offers no advantages for exposure of the abdominal ureter ; its use is limited to a few operations upon the pelvic section. The abdomen is opened by a median or para-median incision from the pubic symphysis to the umbilicus. The full Trendelenburg position is adopted and the intestines are packed aside. The ureter is seen at the brim of the pelvis where it crosses the bifurcation of the iliac artery, and is followed up or down from this point. To expose it the peritoneum over it is incised, when it can be stripped from its bed.

The advantages of the transperitoneal approach are the rapidity and ease with which the ureter is exposed. The disadvantages are the liability to peritoneal infection in septic cases and the difficulty of draining the peri-ureteral space. The disadvantages greatly outweigh the advantages, and the transperitoneal method is used in only a few cases, for instance occasionally for ureterolithotomy in the female ; it is a necessary part of the operation of transplantation of the ureters into the bowel. It is also necessary after certain surgical traumas and valuable when fistula of the ureter has followed extensive gynæcological operations such as panhysterectomy for, in such cases, the lower segment of the ureter is embedded in a mass of fibrous scar tissue and the peritoneum of the pelvis is adherent. Extraperitoneal exposure is then often difficult, and may be impossible.

Complete nephro-ureterectomy has been carried out through a transperitoneal approach, then using a para-rectal or rectus splitting incision, but would never be deliberately chosen.

URETEROLITHOTOMY

About 75 per cent. of calculi migrating from the kidney and temporarily impacted in the ureter are passed without external operation. The stones may be passed naturally or the process may be assisted by the pressure of artificial diuresis aided by belladonna or its derivatives, or as a result of endoscopic measures (p. 1960). In the remaining cases open operation is necessary because of the size and shape of the calculus, hydro-ureter and hydronephrosis, pain, infection, or calculous anuria.

Where a stone is lodged in the ureter simultaneously with a stone in the kidney of the same side, it is the rule to remove the ureter stone first, unless the other kidney is non-functioning or in the presence of calculous anuria, when a primary kidney operation serves the dual purpose of stone removal and nephrostomy, thereby safeguarding against failure of renal function. If the kidney is operated upon first, the ureter stone will be removed endoscopically or incisionally on the return to satisfactory health and recovery of renal function.

The common sites of impaction are at the upper end of the ureter, at the brim of the pelvis, or just outside the bladder in the prevesical spindle. The exposure of the ureter at these levels has been described.

In the lumbar segment the ureter is easily drawn to the wound. If the stone cannot be manipulated into the renal pelvis and removed by pyelolithotomy the ureter is necessarily incised. In the pelvic ureter, when the stone has been impacted for some time, there may be much matting of the peritoneal tissues and the ureter must be mobilized with great care to avoid damage to vessels and bowel. A sling of gauze or a retractor introduced beneath it supports and stabilizes the ureter while it is incised and the stone is removed. The stone is carefully loosened and removed, avoiding fragmentation. A ureteric catheter or bougie is passed down into the bladder to prove patency of the duct, unless endoscopic catheterization has previously been done. One or more stitches of 6/0 catgut are generally used to approximate the outer coats of the ureter. Too many or too closely-placed sutures strangulate the edges and are responsible for delayed healing. Sutures which enter the mucosa, if not absorbed, may encourage further stone formation.

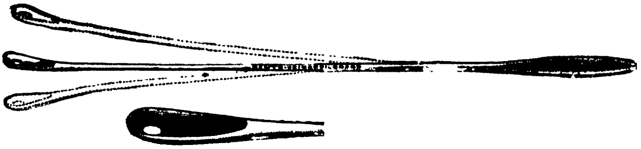

Fig. 958.—Thomson-Walker's ureter stone-scoop.

The region of the ureter incision requires prolonged drainage to prevent accumulation of extravasated urine which would, unless given easy escape, promote abscess formation with delayed healing and the possibility of a persistent fistula or stricture formation.

If a stone lies low in the ureter and cannot be felt in a stout patient, or in the female, the lower ureter being difficult to reach, the tube may be opened at a convenient spot near the brim of the pelvis and Thomson-Walker's flexible ureteral scoop (Fig. 958) introduced. This may be coaxed round and will often deliver the stone. If the scoop fails to disimpact the stone a second incision is made over it and the calculus prised out.

It is important to bear in mind that ureter stones may readily escape *up* the ureter in the course of an operation, a dilated ureter, the Trendelenburg position and a spinal anæsthetic all aiding their migration. For these reasons it is often wiser, in the search for low ureteric stones, to expose the ureter at the pelvic brim and to support it by a gauze sling before actually attacking the supposed position of the stone. I once failed to find a stone at the lower end of the ureter, which X-rays had proved to have lain there for a year. A subsequent X-ray showed the stone to be in the kidney ; it was passed naturally a month after the operation.

During manipulation of the vesical extremity a stone can escape into the bladder. In such a case an incision may be made into the posterior wall of the bladder and the stone removed ; the incision is closed by catgut sutures. No harm will arise if suitable retro-vesical drainage is established, and a urethral catheter is tied in for 3 or 4 days. Removal of the stone from the bladder is, however, preferably carried out with the aid of a Bigelow's evacuator.

OPERATIONS IN CALCULOUS ANURIA

The importance of operation in this condition was proved long ago by the figures given by Morris,* for in cases not operated upon there were only 20.8 per cent. recoveries, whereas 51 per cent. recovered after operation. The main difficulty lies in the determination of the side for operation in bilateral lithiasis ; X-rays and ureteral catheterization help the surgeon to arrive at a decision. The side selected for operation should be that which is, from a study of the history and clinical data, the most recently and consequently the less destructively affected. The nature of the operation depends upon the discovery of a tangible cause ; a stone lodged in the renal pelvis or ureter should be operated on. Radiology will generally indicate that a stone in the ureter, often the ureter of the sole functioning kidney, is responsible, at any rate in those cases where operative interference offers a fair chance of relief. Where both kidneys are choked with stones there is little to expect from surgery. Where a stone is present in the ureter of the kidney which has given evidence of recent activity by pain, an attempt should be made to remove it, if such removal can be carried out by an operation which the patient can stand. A minor operation, the liberating of a stone impacted at the ureteric meatus, or a vaginal uretero-lithotomy, will produce little constitutional disturbance and may be performed even in the presence of pronounced uræmia. Stones higher in the ureter may be so loosely held by the muscle coats of the duct that they will allow the passage past them of a ureteric catheter introduced cystoscopically. This is the process to adopt in impaction in any part, except the extreme ends, and, if so coaxed beyond the stone, the catheter should be left *in situ* to drain the kidney for a week or longer. On its removal urine may escape naturally and the stone not uncommonly passes spontaneously after a short interval, or it may then be removed surgically if the patient sufficiently recovers from the uræmia. Failure to establish catheter drainage in this way will call for immediate nephrostomy. If the stone is impacted in the upper end or in the renal pelvis, the usual renal exposure is employed and the stone removed in the ways described on p. 1921. Temporary nephrostomy, occasionally pyelostomy, even after successful lithotomy, will aid recovery of renal function. The added operative danger of renal drainage when the kidney has already been exposed is minimal. The after-care and especial means for hastening the return of renal function have already been detailed.

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* *Surg. of the Kidney and Ureter*, Vol. II.

URETERECTOMY

Ureterectomy is performed either as a separate operation following nephrectomy after an interval of time, or in combination with it and simultaneously (nephro-ureterectomy). The first to remove the whole length of the ureter were Reynier in 1892 and Poncet in 1893, each being driven to undertake the operation from persistence of sinuses after nephrectomy, performed in the one case for pyonephrosis, and in the other for tuberculosis. Howard A. Kelly[*] was the first deliberately to attempt primary one-stage nephro-ureterectomy, and he reported three cases in 1896, tuberculosis being the indication in each. Primary removal of the whole length of the ureter, supplemental to nephrectomy, being an operation of considerable magnitude, has naturally been accepted with reluctance and, further, in the vast majority of examples of ureteritis secondary to renal infection, whether tuberculous or pyogenic, resolution is satisfactory after nephrectomy with partial ureterectomy. The lumbo-ilio-inguinal incision originally adopted by Morris, Kelly, Albarran and Israel for the radical operation jeopardized the muscles and nerves of the abdominal wall and, no doubt, brought the operation into further disfavour. In 1911 Lilienthal[†] called attention to the complications of the tuberculous ureter stump and described a two-way approach by which the abdominal muscles were preserved, the ureter being exposed through a separate iliac muscle-splitting incision. This principle for performing nephro-ureterectomy has become universally adopted. Amongst those who are responsible for its establishment are Kidd, Swift Joly, Judd and, more recently, E. Papin.

Surgeons still differ in their choice of approach to the pelvic ureter. Some prefer the oblique route, the muscles being split or divided, whilst others adopt a vertical incision placed mesially from the umbilicus to the symphysis pubis or, more laterally, through any part of the rectus sheath, the rectus muscle then being split or displaced. Vertical incisions seem to offer a better approach to the juxtavesical and intra-mural ureter, allow more complete mobilization of the bladder, are drained with greater safety, since tubes or other devices do not lie in contact with the iliac vessels, and, in my experience, do not predispose to incisional hernia. All the operations are performed extraperitoneally, the transperitoneal route having been abandoned many years ago as an operation of choice.

Interval ureterectomy is required where the ureter stump fails to atrophy to a fibrotic cord and remains evidently the seat of a pathological process. The indications for its removal are (1) papillomatosis ;

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[*] *John Hopkins' Hosp. Bull.*, March 31, 1896, vii, 31.

[†] *Ann. Surg.*, 1911, liii, 521.

(2) tuberculosis ; (3) hydro or pyo-ureter, where the lower end is (*a*) obstructed by a stricture or a stone, or (*b*) unduly patent, when the stump is in fact a bladder diverticulum, probably infected.

(1) **Papillomatosis.**—Cystoscopic recognition of the escape of blood from the orifice of the stump indicates the presence of transplant growths in any part of the length, including the intra-mural section.

(2) **Tuberculosis.**—Thomson-Walker* found that 8 per cent. of his cases required a late ureterectomy. He, like the majority of surgeons, preferred nephrectomy and partial ureterectomy as a primary step, deferring a review of the ureter for six months. Persistence of T. bacilluria and cystitis in the presence of a healthy opposite kidney indicated removal of the ureter to the bladder.

(3) **Hydro- or pyo-ureter.**—In this group, colicky pain and persistence of pyuria provide evidence of trouble arising from the stump. Radiography may aid the diagnosis by revealing a calculus shadow. If an opaque catheter can be introduced, its position will indicate the size and shape of the cul-de-sac, and this will be more precisely defined if an opaque medium is injected through the catheter.

If dilatation of the orifice or meatotomy followed by a course of lavage fail to relieve symptoms, excision of the stump is required. Unfortunately in these cases the operation may be an exceedingly difficult one, owing to peri-ureteritis with dense adhesions.

Technique of ureterectomy.—Where a short stump is presumed, the ureter is exposed through a median sub-umbilical incision. If a length of the abdominal ureter probably also remains it is better to incise an inch from the mid line, so that the rectus muscle may be split up for whatever length is found to be necessary. The ureter is exposed (*see* p. 1947) at the pelvic brim and traced up to its highest point. Separation here may be difficult, from adhesions, and the high Trendelenburg position with wide retraction is necessary. At the brim the ureter is separated with great care from the iliac vessels, a gauze sling is placed beneath it and held in forceps. The course in the male, to the point of crossing by the vas, and in the female to the base of the broad ligament (that is to where it passes beneath the uterine artery) is usually exposed without great difficulty. Juxta-vesical removal requires the exposure of a further 1½ to 2 inches of the tube and, to render this less difficult and dangerous, methods have been devised to mobilize the bladder by which the intra-mural region is elevated. Since this viscus is anchored largely by the strong attachment of peritoneum for an area of 5 to 6 cm. in diameter surrounding the urachus, either this area may be detached by patient dissection or E. Papin's method of " extraperitonization " of the bladder may be adopted.† In this the bladder is cleared by blunt dissection laterally and from above downwards as far as possible until this becomes difficult from peritoneal attachment. The peritoneum is then deliberately incised and this incision is continued laterally while drawing the bladder upwards and forwards. The disc of peritoneum excluded from the rest of the sac remains adherent to the bladder and the gap is sutured. As the result of this step, the bladder, held up by forceps or a stitch, can be raised, retracted or rotated, and the structures crossing the termination of the ureter may be seen and handled with relative ease (Fig. 959). The vas is easily seen and held aside. The uterine, superior and middle vesical arteries appear as tense strands in the fibro-fatty tissue. All such strands must therefore be double-clamped before division and carefully ligatured. Greater difficulty in providing hæmostasis may be presented by the venous plexus which surrounds the ureter, especially developed in multiparæ. In some cases I have had to resort to packing as the only means of checking bleeding from these veins. When the larger arteries have been divided and the bladder is satisfactorily elevated, the ureter comes more and more into view and soon traction upon it is seen to draw up a knuckle of bladder wall. If the case is one of tuberculosis the ureter is grasped in a clamp placed flush with the bladder wall and a second clamp is placed a quarter of an inch higher. The ureter is divided between these with a cautery or carbolized knife and both ends are ligatured with 2/0 catgut. Cauterization of the lumen or excision of the intra-mural ureter introduces the risk of wound infection from the bladder and is therefore better avoided.

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* *Brit. Med. Journ.*, 1927, ii, 625.

† *Arch. des Mals. de Reins etc.*, 1936, x, 1.

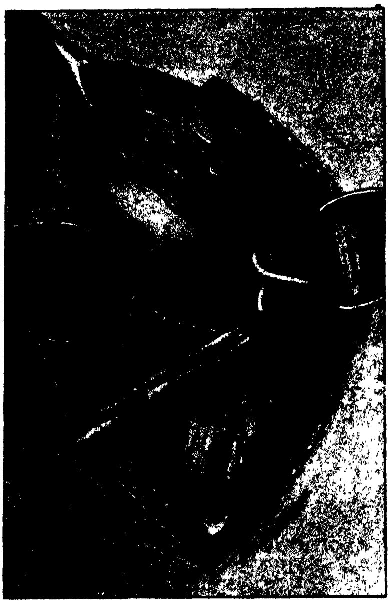

Fig. 959.—Exposure of lower end of right ureter.

Papin's method of bladder extraperitonization has been employed. The relation of the vas and vesical vessels to the ureter is seen.

In the remainder of the cases, with the exception of papillomatosis a similar procedure is adopted. In papillomatosis especial attention must be given to the intra-mural ureter, either the whole of its extent is surrounded by a diathermy knife incision so that a disc of bladder wall is taken with the ureter, or a wider area of bladder is included in the presence of a local vesical transplant. In this case it will be necessary to open the bladder anteriorly in order to excise the growth from within. The gap in the bladder is finally sutured, and retrovesical drainage established. Where papillomatosis is suspected, or purely as a prophylactic measure, the intra-mural channel may be fulgurated before the lower ligature is applied, as J. C. Colston has advised.*

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* *Journ. Urol.*, 1933, ii, 110

Nephro-ureterectomy.—This may be performed as a one-stage operation if that is within the capacity of the patient's endurance; otherwise it is customary to defer the ureter removal for two to three weeks, when the technique will not differ from that already described. If performed in one stage, it is preferable to free the kidney before the ureter for these reasons: (i) Since nephrectomy *may* only be necessary it would be unreasonable to excise the ureter as a primary step. (ii) If the patient is suffering from operative distress discontinuance is easier. In uretero-nephrectomy skin implantation would be necessary until recovery was sufficiently advanced to warrant nephrectomy. (iii) It is easier to turn the patient on the table from the lateral to the Trendelenburg posture.

The kidney is freed by the usual lumbar method and the vascular pedicle is ligatured and divided. The ureter is separated down as far as the lumbar incision permits, that is to the pelvic brim. The kidney, suspended on the ureter, is left outside the lower end of the wound, which is sutured beneath it in layers. The patient is then placed in the Trendelenburg position and a median sub-umbilical incision is made. The ureter is exposed in the pelvis in the manner already described; its position is rendered more obvious by traction on the kidney, which puts it on the stretch (Fig. 960). The remainder of the technique for the ureter is the same as described on p. 1955. By traction on the kidney it, with the whole length of the ureter, will come away in continuity. The hypogastric wound is sutured except where traversed by a tube which drains the pelvic cellular tissue. The loin need not be drained.

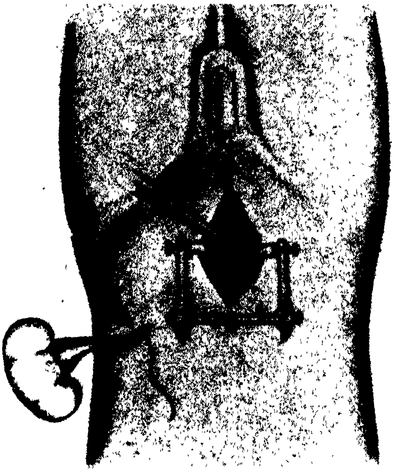

Fig. 960.—Left nephro-ureterectomy. The lowest superficial and deep stitches are placed but not tied until the kidney and ureter are removed, in case adhesions remain at the pelvic brim more easily freed from above.

If the ureter is freed as a primary step (uretero-nephrectomy) the Trendelenburg posture is first adopted and the pelvic ureter is divided at the bladder end and freed as high as possible. The wound is sutured, except where a drainage tube traverses the abdominal wall to the pelvic floor. The patient is then placed in the lateral position and the kidney exposed. Separation of an enlarged adherent kidney is aided by an immediate finding and tracing up of the freed ureter to the renal pelvis (Gutierrez). Lumbar drainage is unnecessary.

The indications for nephro-ureterectomy are the same as for

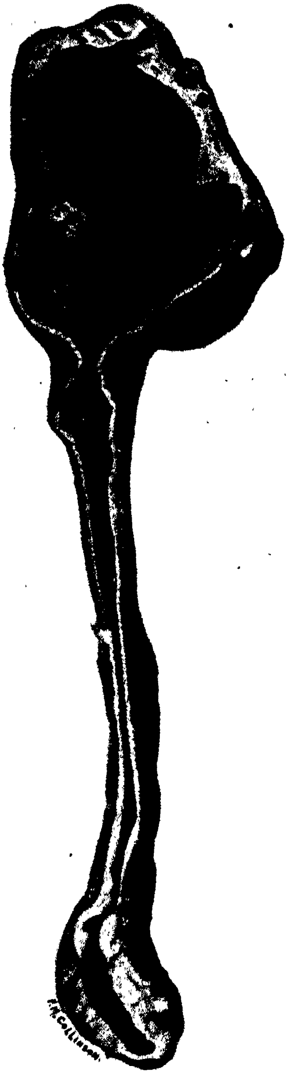

Fig. 961.—Diffuse lithiasis of the kidney and whole length of the ureter.

(Woman aged 42.) Juxta-vesical nephro-ureterectomy performed by the writer.

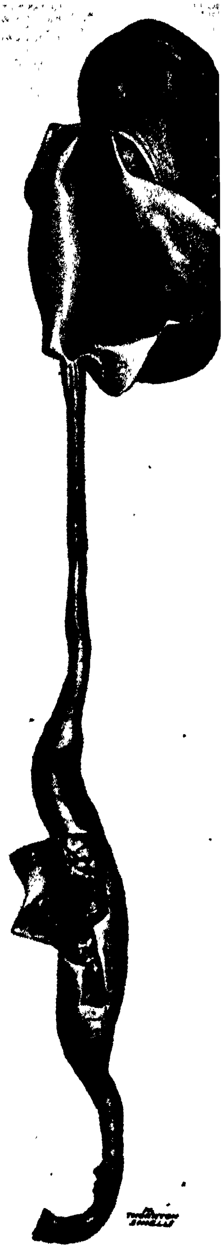

Fig. 962.—Primary papillomatosis of the ureter with transplants at the vesical end.

The kidney is hydronephrotic but the upper ureter is not dilated. Removed by juxta-vesical nephro-ureterectomy from a woman aged 62.

ureterectomy (p. 1954). In papilloma of the renal pelvis, J. Swift Joly* proved the necessity for the primary radical operation. Opinion remains divided on the advisability of primary nephro-ureterectomy in renal tuberculosis. Lett† reviewed the complications arising from the tuberculous stump and urged wider adoption of primary ureterectomy to avoid them. Many surgeons are guided by the characters of the ureter when seen and handled in the loin at nephrectomy, but I think this assessment is unreliable (Figs. 962, 963), for among the examples in my personal series, in at least four the upper ureter presented a normal appearance but the lower two or three inches were the seat of caseous foci or areas freely studded with miliary tubercles, strongly in contrast to the apparently healthy upper end. Beer‡ found it necessary to perform primary nephro-ureterectomy in 7 per cent. of his cases, a figure comparable to Thomson-Walker's (p. 1955). In two cases of late ureterectomy which I performed 4 years and 2½ years after nephrectomy by other surgeons, where severe cystitis persisted, there was evidence of active tuberculosis in each of these still patent ureters. The gravity of the combined operation is necessarily a deterrent in the aged, the stout, or in the presence of

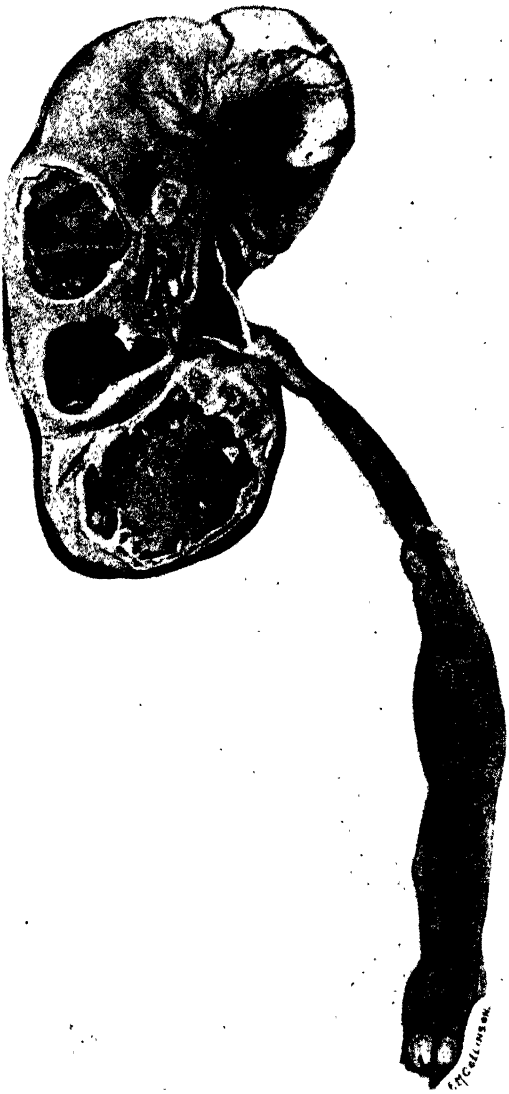

Fig. 963.—Ulcero-cavernous renal tuberculosis with ureteritis and a breaking-down caseous focus at the vesical extremity.

(Male aged 17.) Juxta-vesical nephro-ureterectomy performed by the writer.

(Figs. 959–963 are reproduced from Proc. Roy. Soc. Med. by permission of the Honorary Editors.)

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* *Fifth Congress Internat. Soc. of Urol.*, 1933, p. 211. † *Lancet*, 1936, ii, 1313. ‡ *Journ. Urol.*, 1933, xxix, 135.

pulmonary or other extra-urinary lesions, but in favourable subjects the operation is well withstood, and in my series of 30 cases not only has there been no postoperative mortality, but the duration of convalescence, as measured by the postoperative stay in hospital, is approximately the same as after nephrectomy alone. It has not appeared to me that patients who have survived the major operation are the worse for its performance ; on the contrary they enjoy a more rapid return to health and are safeguarded against the consequences of the ureteral stump which, though not common, are of grave importance when they do arise.*

The Surgery of the Intramural Ureter and the Ureteric Meatus

Urography and facilities offered by the several varieties of endoscopes are the foundations of a new chapter in the surgery of this limited though very important region of the genito-urinary apparatus, which includes the following among its more important subjects :—

1. *Congenital defects*, the pinpoint meatus associated at times with ureterocele, valves and intramural stricture. Pressure from vesical diverticula.

2. *Acquired obstructions*. (i) Impacted stone. (ii) Strictures, meatal or intramural, from inflammatory fibrosis and following impaction or passage of a stone. (iii) Strictures following a previous operation or radium therapy (*see* p. 1974). (iv) Tuberculosis, where the obstruction is due to active or healed tubercle, or to the tuberculous systolic bladder (*see* p. 1964). (v) " Adnexal disease," a chronic inflammatory process extending into the ureter wall from chronic seminal vesiculitis, usually post-gonococcal in the male, and from cervical or tube infection in the female. (vi) New growths, papillomata and carcinomata. These are rarely primary ; they are usually associated with bladder growths or secondary to those in the ureter, either by direct spread or by transplantation (*see* p. 1959).

Methods at the surgeon's disposal for treatment of these pathological conditions are : (1) Endoscopic dilatation. (2) Endoscopic endothermy meatotomy or fulguration. (3) Uretero-lithotomy, transvesical or vaginal. (4) Plastic surgery upon the ureter meatus (transvesical). (5) Uretero-vesical anastomosis (lateral, extravesical). (6) Resection of the intramural canal. (7) Transplantation.

(1) **Endoscopic dilatation.**—Some form of operating cystoscope with a channel wide enough to admit a whip- or bulbous-ended bougie is preferable. The McCarthy panendoscope (Fig. 1015, p. 2081) and the Swift Joly cystoscope are instruments well suited for this purpose. Periodic dilatations for prolonged periods may be necessary. This treatment is employed for non-specific inflammatory strictures. If used to aid the passage of impacted calculi, dilatation may be followed by a trial of the ureter spiral, probang, multiple catheters, or other of the

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* *Pres. Add. Proc. Roy. Soc. Med.*, 1940, xxxiii, 295.

many devices designed for this purpose. A ureteric catheter indwelling for one to three days may result in slow dilatation and passage of the stone.

(2) **Endoscopic endothermy, meatotomy and fulguration.**—If dilatation fails, a catheterizing cystoscope of the Wolff type is introduced and the meatotome (Fig. 964 (*a*)), with wire retracted into its insulated sheath, is passed along the catheter channel and advanced towards the ureter opening. If a stone is visible, checked by a meatal ring, a minute touch with the exposed wire, endothermally charged, will suffice to free the stone. If the stone is at a higher level (up to one inch) a double catheterizing cystoscope is used. A catheter is passed through one channel and up the ureter to the stone; the meatotome is introduced through the other channel. The catheter *in situ* acting as a guide, a cut is made upon it exposing the buried length and this will provide an opening large enough to allow subsequent passage of the stone. (Fig. 965.)

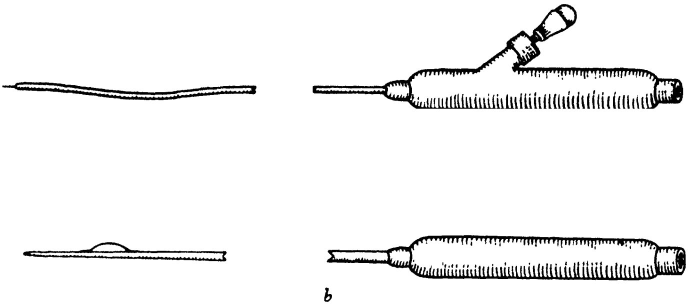

Fig. 964.—Ureter meatomes.

(*a*) For incision from the vesical aspect.
(*b*) For incision from within the ureter, the curved wire being the cutting agent.

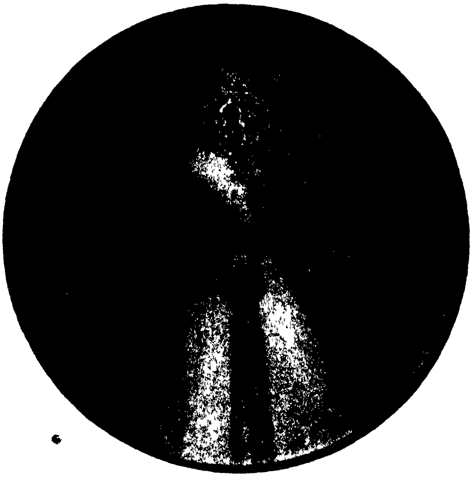

Fig. 965.—Ureter meatotomy to assist escape of a stone ½ to 1 inch above the ureteric orifice : the meatome incises upon a catheter which has been passed up to the stone. A double catheterizing cystoscope is required for this operation.

A ureter meatotome (Fig. 964 (*b*)), also suitable when the stone is at a higher level and a greater length of ureter must be incised, carries a wire loop ¾ inch from its distal end. This incises the ureter in a manner comparable so that in which the triangular blade of a Maisonneuve's urethrotome it made to incise a stricture of the urethra.

For a ureterocele the high frequency electrode introduced through a catheterizing cystoscope offers a simple and efficient treatment. The cutting current is preferable on account of its more rapid effect, especially where a stone is lodged in the dilated ureter above. In this case incisions are made with the ureter meatotome radiating from the ureter orifice, which, if pinpoint, may have been disclosed by a preliminary intravenous injection of indigo carmine. If a coagulating current only is available the whole surface is penetrated and scarified with the type of electrode used for papilloma fulguration. Where a stone is lodged, rectal or vaginal massage may help to deliver it into the bladder after any of these operations. It may be immediately removed with a Bigelow's evacuator.

(3) **Ureterolithotomy.**—If meatotomy and the other endoscopic measures fail, some form of open incisional method is required. Transvesical operations approach the stone either (*a*) through the ureter meatus, or (*b*) through a fenestra in the bladder wall (the Thomson-Walker method).

(*a*) **Transvesical meatal incision.**—In this the bladder is opened but, before the Trendelenburg posture is adopted, it is wise to palpate the stone and to endeavour to anchor it by transfixion with delicate tenaculum forceps placed immediately above it, for stones lying in this position may be dislodged and are apt to escape *up* the dilated ureter, aided partly by the relaxation of the ureter wall from the anæsthetic, and partly by the elevated posture. Having so fixed the stone and raised the table, an illuminated bladder retractor is put in position and displays the ureter orifice. An incision, by knife or endothermy current, is made over a probe passed to the stone, and the stone is removed. If, in spite of the precautionary fixation, or because the stone cannot be fixed, it should escape, an attempt may be made to catch it with a spiral. If this fails, the ureter must be exposed extravesically and the operation proceeded with as described in the abdominal approach (p. 1948).

The operation may be completed by closure of the bladder with a double row of sutures, an intied catheter being employed for bladder drainage for the first few days. Closure of the bladder is contraindicated in the presence of vesical sepsis, for the risk of ascending infection would then be considerable, since the sphincter at the lower end of the ureter has been destroyed. Any operation which destroys the sphincter is apt to be followed by vesico-renal reflux or backflow. Severe pain may follow, and this or ascending sepsis may necessitate subsequent nephrectomy or nephro-ureterectomy where a greatly dilated ureter was present.

(*b*) **Thomson-Walker** devised an operation to preserve the intramural protective mechanism :—A curved incision with the concavity towards the trigone is made 1½ inches outside the ureteric orifice. A flap of bladder wall is marked out and turned downwards, and by traction upon it the outer surface of the ureter is placed on the stretch and is readily recognized ; the stone is felt and removed by incising the ureter. The operation is completed by ureteral sutures and partial closure of the window, leaving sufficient space to transmit a small tube for the drainage of the peri-ureteral cellular tissue. This approach presents advantages over an abdominal extraperitoneal where there is excess of fat or scar tissue, and in the female.

Vaginal ureterolithotomy (Garceau*).—This operation is very apt to cause a uretero-vaginal fistula, and is only justifiable in the extreme circumstance of calculous anuria, as it can be performed under local or gas-oxygen anæsthesia if the stone is palpable vaginally. The cervix is grasped with volsellum forceps and drawn to the opposite side. The vaginal wall so stretched is easily incised, the ureter is exposed and the stone removed. The ureter should be sutured, if possible.

(4) **Plastic operations.**—These are called for where endoscopic dilatation or incision fail in the treatment of stricture. Thomson-Walker's method is to expose the bladder base thoroughly by suprapubic cystotomy. A grooved probe is then passed up and the ureter slit for ¼ inch. A stitch is then inserted into each edge and the wound held open while a further ¼ inch incision is made. A third pair of stitches is then inserted, and finally a single stitch is placed at the superior angle of the wound when a gaping orifice large enough to admit the little finger will be found. A small rubber drainage tube is passed up the ureter and stitched to the edge of the opening : its proximal end passes out of the cystotomy opening alongside the bladder drainage tube.

(5) **Uretero-vesical anastomosis.**—In the presence of great dilatation of the ureter secondary to a stricture or valvular obstruction, lateral anastomosis between the dilated ureter and the adjacent bladder may be simply and speedily performed. The lumen of each is opened by a parallel incision ; watertight suturing is unnecessary since retro-vesical drainage is established, and the bladder is kept empty for ten days by an in-dwelling catheter or a suprapubic tube. I carried out this operation successfully in a boy of 14,† where a valve was presumably the cause of ureteromegaly. This operation was performed eleven years ago and a recent pyelogram shows that hydronephrosis has almost disappeared, confirming the absence of reflux.

6. **Resection of the intramural canal.**—This is part of ureterectomy and is discussed under that heading, *see* p. 1955.

TRANSPLANTATION OF URETER

An operation for the transplantation of a ureter may be required in the treatment of the following pathological conditions of :—

The bladder.—(1) *Congenital malformations*, as the operation of choice in all cases of ectopia vesicæ or complete epispadias with incontinence.

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* *Boston Med. Journ.*, April, 1904, cl, 426.

† *Proc. Roy. Soc. Med.*, April, 1932, xxv, 1683.

(2) *New growths*, simple and malignant, involving the region of the ureteric orifice, where partial cystectomy, including the lower end of the ureter, is required.

(3) *Vesico-vaginal fistulæ* of such size as to prohibit repair, notably those following radium burns.

(4) As a preliminary to total *cystectomy*.

(5) In some cases of true *incontinence of urine*.

The ureter.—(1) *Congenital conditions.*—If one of the ureters or a supernumerary ureter opens into the vagina or into the urethra, transplantation is the only satisfactory alternative to nephrectomy or nephro-ureterectomy to cure the discomfort from incontinence of urine.

(2) Some cases of *trauma*, mainly gynæcological.

(3) *Inflammatory conditions.*—Cases in which there is destruction or a stricture of the ureter due to inflammation either in or around the ureter.

(4) *New growths.*—Transplantation or nephrectomy must be performed where operative treatment is adopted for new growths of the pelvis or abdomen involving the ureter, and the length of ureter to be removed is too great to allow anastomosis between the proximal and distal ends.

(5) Compression of the intra-mural ureter by the "systolic" bladder, as found in some cases of vesical tuberculosis.

The ureter may be transplanted into (*a*) the bladder ; (*b*) some part of the intestinal canal ; (*c*) the skin.

The complications to be feared are ascending infection, obstruction and vesico-renal reflux.

(*a*) **Transplantation of the ureter to the bladder (ureteroneocystostomy).**—**Indications.**—(1) As a part of the operation for resection of a bladder growth or diverticulum involving the ureteric orifice (implantation and transplantation).

(2) For uretero-vaginal fistula, congenital or traumatic (surgical or obstetric).

(3) Stricture or valve of the lower end of the ureter.

Implantation.—Where, in the course of intravesical operations, partial cystectomy or diverticulectomy, the ureter is recognized in the depth of the vesical wound thus formed, it may be fashioned to the bladder with precautions to avoid risk of stricture ; extravesical mobilization is then unnecessary.

Transplantation.—Freeing the ureter outside the bladder is an essential step in transplantation. Additional requirements are that the new meatus should be sufficiently large, and that the ureter should be applied to the bladder without tension or kinks. Attempts to imitate the natural anatomical arrangement, in which reflux is prevented by procuring an oblique intramural course and a quasi-sphincteric control, does not, so far, appear to have met with success. A technique adopted by Marion and described in his text-book, in which the ureter is given a short intravesical course in a submucous tunnel, may aim at this objective. The main object is good drainage, hence an opening large enough to allow for a subsequent cicatricial narrowing should be striven for. Vesico-renal reflux is a less-to-be-feared complication than back pressure from a stenosed orifice.

Technique.—The steps in transplantation as carried out by Thomson-Walker are :—(i) *When performed for a low ureteral trauma resulting in ureterovaginal fistula.* A vertical subumbilical incision in or close to the midline is made with the patient in the Trendelenburg posture. By an extraperitoneal approach the ureter is exposed as it crosses the pelvic brim by freeing the peritoneum from the lateral pelvic wall and bladder (*see* p. 1948). It is traced down into the dense fibrous tissue in which it lies in the depth of the pelvis. Division of the round ligament permits easier mobilization of the peritoneum, the uterus and parametrium. Unavoidable peritoneal tears may be a help rather than a hindrance, a finger within the serous sac aiding recognition and separation of the ureter to a lower level than could have been accomplished purely extraperitoneally. A probe passed down the ureter through a puncture will further aid separation. The ureter is divided at the lowest limit possible and its end is prepared by fashioning it into two flaps made by incisions on either side of its circumference. The bladder is next opened in the midline anteriorly, a suitable area on the posterior wall of the bladder is selected, to which the ureter may be brought without tension, and into it a 1.5 cm. incision is made. The ureteral end flaps are each transfixed by catgut sutures threaded on short, narrow, curved round-bodied needles ; and these are passed through the new opening into the bladder cavity. The needles transfix the coats of the bladder wall 1 cm. from the new opening and the sutures are tied outside the muscle coat. Two or three tension sutures are passed between the outer coats of the ureter and the bladder muscle (Fig. 966). A narrow drainage tube is inserted between the implanted ureter and the edges of the new opening to which it is held by one catgut suture. Its distal end will be carried through the anterior cystotomy incision and stitched to skin alongside the main bladder drainage tube. The tube, as well as serving for drainage, provides extra space for subsequent cicatricial contraction.

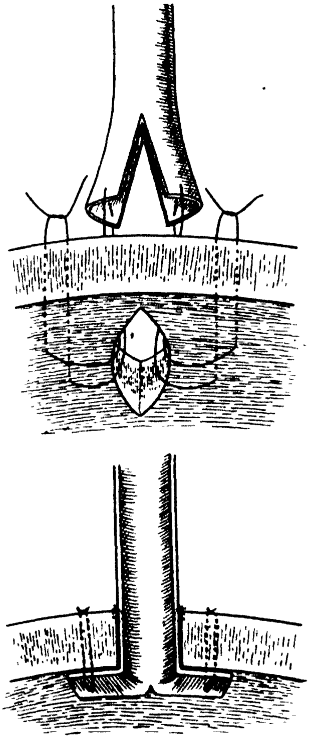

Fig. 966.—**Transplantation of the ureter to the bladder.**

Vertical incisions procure terminal flaps which are transfixed by mattress sutures, and these are carried through the bladder stoma and subsequently through the whole thickness of the bladder wall to be knotted on the muscle coat. (The tube referred to in the text is not shown.)

(ii) *When performed after partial cystectomy for tumour or diverticulectomy.*—The procedure varies but little from (i). Cystotomy and partial cystectomy are the primary steps. After removal of tissue invaded by growth in which the ureter is involved by the transvesical route, the bladder is turned aside to give approach to the ureter as it traverses the pelvis. The ureter-end, after division, is fashioned and fixed as before by the double flap method into one end of the wound remaining after cystectomy, if this can be accomplished without tension; otherwise this wound is completely sutured and the ureter is anastomosed at a higher level as in (i). After fixation of the ureter in the cystectomy wound and insertion of the para-ureteral drainage tube, several stitches traversing all bladder coats will be required to reduce the wound.

Amongst alternative steps in technique adopted by Marion are: (1) The ureter is exposed and separated transperitoneally. (2) Where no intravesical procedure had been required, the ureter is implanted through a stab-wound without the aid of an anterior cystotomy opening. In such cases the bladder is drained through an intied catheter. (3) A catheter is passed up the ureter and left *in situ* for a fortnight to drain the kidney; it will leave the bladder either by an anterior cystotomy opening, or by traversing the urethral catheter.

(*b*) **Transplantation of the ureter into the intestine.**—Amongst the early pioneers to endeavour to divert the urine from the ureter to the bowel was Simon (1851) who, by passing a thread suture between the ureter and the rectum, caused a fistula between these structures. However, it is Chaput to whom credit is due for the origin of the method which is now frequently adopted and is to-day known as the Coffey operation.

Chaput in "De l'Abouchment des Uretères dans l'Intestin,"[*] described experiments upon dogs and operations upon human subjects, giving as his indications for the latter: the ureter injured too high up for implantation into the bladder, exstrophy, uretero-vaginal fistula, vesico-vaginal fistula, certain cases of tuberculosis and cancer of the bladder as a preliminary to total cystectomy. "The operation is one of necessity not of choice and is only done when nothing else can be offered to preserve the kidney function." The ascending or descending colon was preferred, the open end of the cut ureter being sutured by end-to-side anastomosis to the bowel. If the ureter was narrow its terminal inch was buried in the bowel wall by placing a series of sero-muscular sutures (comparable to a Witzel gastrostomy). He recorded a number of successful results. Stiles[†] successfully implanted the ureters in two children suffering from ectopia, and I am grateful to Mr. Henry Wade and Sir Harold Stiles for permission to show a recent excretion urograph of one of these cases 29 years after the operation (Plate VIII); the almost perfect anatomical and physiological state is

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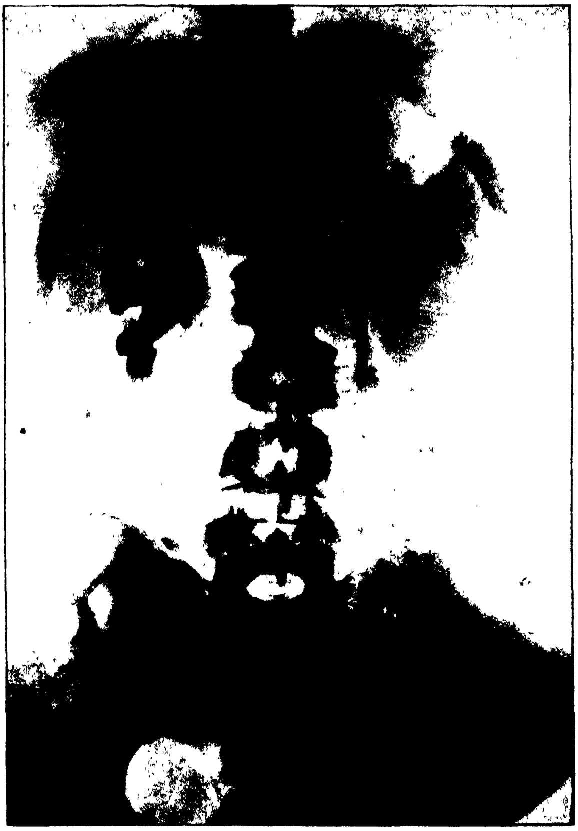
[*] *Arch. gen. de Méd.*, January, 1894, clxxiii, 1.

[†] *Surg. Gyn. and Obst.*, Aug., 1911, xiii, 127.



Excretion urogram fifteen minutes after the injection of uroselectan-B. Investigation made twenty-nine years after bilateral ureter transplantation into the colon by Sir Harold Stiles.

(*Reproduced, by permission, from The Edinburgh Medical Journal*)

PLATE VIII.

apparent and reflects the excellent functional result this patient has enjoyed for a quarter of a century.*

Stiles' method differs from Chaput's in that the open ureter is invaginated through the bowel opening by a catgut suture threaded to two needles which transfix the bowel wall from within out ; when the suture is knotted the ureter is drawn into position. The terminal inch of ureter is embedded in a longitudinal furrow in the bowel wall as in Chaput's operation. Grey Turner modified this method, embedding the ureter in an oblique track formed by the folded-over bowel wall. He described 17 cases of the operation performed for ectopia vesicæ.† Seven years later he was able to show pyelograms of several of these cases.‡ Many of his patients are now alive and well as long as 30 years since operation. From his original article the following notes are extracted :—

Grey Turner's operation.—In ectopia a vertical incision is made from the position of the umbilicus down to but not through the dense fibrous tissue that surrounds the upper border of the exposed bladder. The intestines are packed away and the sigmoid and upper rectum fully exposed. The right ureter is implanted first and is easily recognized from its position and the vermicular movements. The point of implantation is selected about 2½ to 3 in. from the bottom of the recto-vesical pouch. The ureter is exposed by incising the parietal peritoneum, picked up and cut across. The lower stump is tied with catgut and carbolized. The upper free end is carefully separated by blunt dissection for not more than 2 to 2½ in. and the small ureteral vessels carefully preserved. A small (⅜ in.) transverse incision is made through the longitudinal band on the large bowel at the point indicated. The mucous membrane is exposed, pulled up and incised. The upper end of the ureter is trimmed obliquely and a catgut suture (3/0 chromic gut) is passed through its pen-nib end and tied. One end of this suture is cut, leaving 3 in., and this is coaxed into the open mouth of the ureter and acts as a urine quill (Charles Mayo), thereby allowing escape of urine into the bowel past obstructive œdema at the new junction. The long end of the suture is threaded on a curved needle, passed into the lumen of the bowel, and pierces the wall from within half an inch lower down. The ureter is drawn into the lumen of the bowel and the suture tied. Six interrupted sero-muscular sutures (3/0 chromic gut) are introduced so as to bury the ureter by folding the wall of the bowel over it. The lowest suture is just above the fixation suture and the others about ⅜ in. apart, the second and third just catching the sheath of the ureter. The ureter is buried obliquely in the wall so that it passes without kinking from the pelvic wall to the bowel. A second row of sutures buries the fixation suture and the first row, and two additional sutures pass from the wall of the bowel to the edges of the peritoneal incision. A fine rubber tube is brought from the area of anastomosis through the lower end of the abdominal wound. The parietal incision is closed and a large self-retaining rubber catheter is placed in the rectum for 4 days.

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* *Edin. Med. Journ.*, 1939, xlvi, 61.

† *Brit. Journ. Surg.*, July, 1929, xvii, 114.

‡ *Brit. Journ. Surg.*, Jan. 1936, xxiii, 580.

Implantation of the second ureter is deferred for 2 or 3 weeks and then the original wound is re-opened. The second ureter is implanted in a similar manner at a slightly higher level. The results of this operation are discussed under Ectopia Vesicæ (p. 1991). In a personal communication Grey Turner states that he now lays the ureter in an oblique submucous bed (as shown in Fig. 967), and omits the catgut guide and drainage tube.

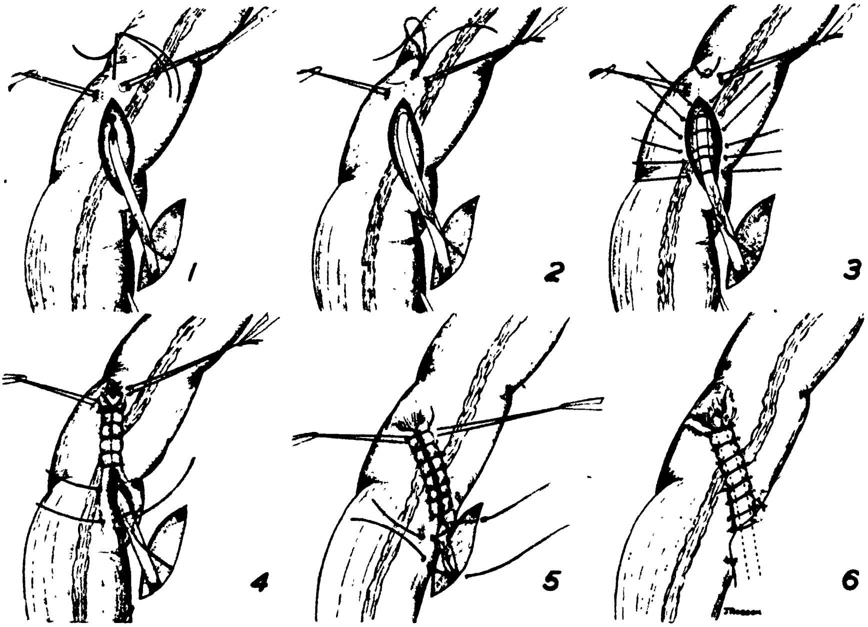

Fig. 967.—Uretero-colic transplantation. Grey Turner's method.

1, Three guide sutures have been introduced. The ureter being laid in its submucous bed, the fixation stitch has been passed through the bowel wall half an inch below the lower end. 2, Fixation stitch taking a secure hold of bowel wall. 3, Fixation stitch tied, sutures in position in muscular coat. 4, These sutures tied and covered by peritoneal Lembert sutures. 5, Fixation stitch buried, last Lembert sutures taking up edge of parietal peritoneum. 6, Completion. Notice that ureter passes directly from extra-peritoneal bed into bowel without kinking. The guide sutures have been removed

Coffey's operation.*—This operation aims at making the ureter travel for some distance beneath the intestinal mucous membrane before opening into the lumen of the bowel. The ureter is freed as far as necessary, double clamped, divided, cauterized and the lower stump ligatured (Figs. 968, 969, 970).

Four traction stitches to put the bowel on the stretch are inserted and grasped by forceps. An incision 1½ in. long is made through the seromuscular coats in one of the longitudinal bands. The ureter end is transfixed by a curved intestinal needle carrying a fine catgut

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* *Journ. Amer. Med. Assoc.*, Feb. 11, 1911, lvi, 397.

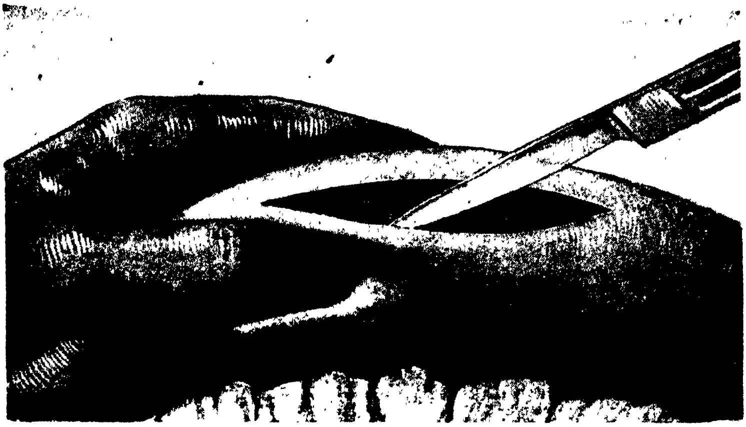

Fig. 968.—Ureteral implantation into bowel (Coffey's method) : incision of muscular coat.

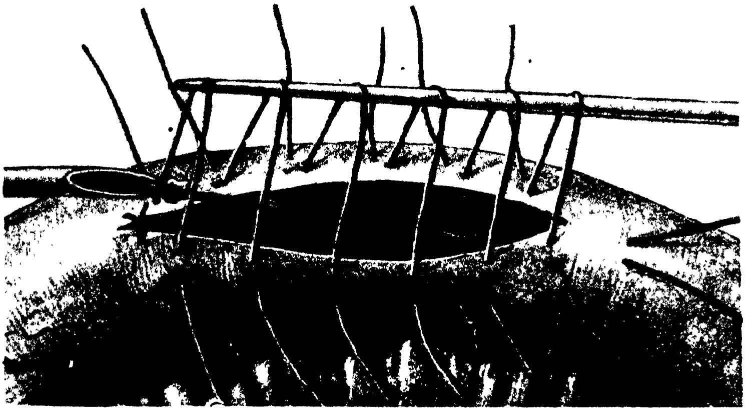

Fig. 969.—Ureteral implantation into bowel (Coffey's method) : end of ureter being drawn through opening in mucous membrane.

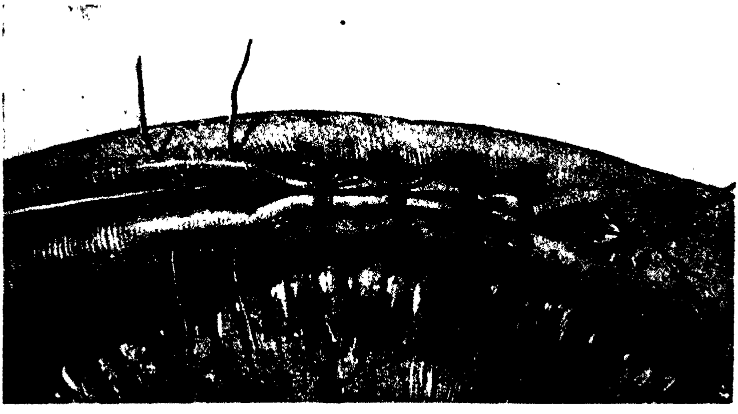

Fig. 970.—Ureteral implantation into bowel (Coffey's method) : tying bowel sutures.

suture. The suture is tied, leaving two long ends. If the Mayo method (*vide supra*) is adopted, one end is cut to a 8 in. length threaded on a coarse needle, which is passed blunt end first up the lumen of the ureter and withdrawn, leaving the stitch end *in situ*. Otherwise the two ends are left long and threaded on two curved intestinal needles. The mucosa is stabbed at the lower end of the bed, and through the hole thus made the stitch-carrying curved needle enters the bowel lumen. The needle emerges ½ in. below the stoma, unthreaded and the end tied, bringing the ureter neatly into place. A series (6 to 8) of sero-muscular stitches buries the ureter in the bowel wall, the alternate ones, commencing at the lower end, picking up the outer coats of the ureter. These sutures were actually placed in readiness in the original Coffey technique before constructing the ureteral bed. A second reinforcing series of sutures buries the ureter still further and consolidates the anastomosis. The peritoneal gap through which the ureter was dislocated is closed and the bowel is attached over it by sutures, thus preventing a twist or kink of the ureter.

Coffey has further developed this operation by thorough cleansing of the lower bowel and by placing a specially prepared catheter with rubber cuff in the ureters, with the intention of preventing ascending infection in the early stage of convalescence, as well as to ensure easy escape of urine from the kidney which, without the ureteral tube, would be obstructed by œdema in the ureter (the Coffey No. 2 operation). With this modification, therefore, bilateral implantation may safely be employed at one sitting. These tubes, which were subsequently modified by Kidd, are brought outside the anal orifice. They tend to become detached about 10 days after operation, by which time risk of infection at the union will have passed. For the detailed description of these operations, and a third modification, the reader is referred to the original article by R. C. Coffey,[*] or to the Medical Annual, 1930, p. 537, as well as to subsequent contributions by Nitch, B. J. Ward, and Walters.

Henry Wade[†] offered valuable suggestions in selection of cases, pre-operative precautions, operative technique and postoperative care. In addition to those generally recognized as suitable, he adds cases of intractable cystitis and back-pressure hydronephrosis, the outcome of the systolic bladder of advanced tuberculosis, here transplanting the ureter of the remaining kidney and thereby preserving its function. Additional precautions in pre-operative preparation are to exclude the possibility of supernumerary ureters by excretion urography and to be sure that the rectal sphincter is competent and that no hæmorrhoids are present. The operation is carried out under twilight sleep, procured by two preliminary injections of morphine and scopolamine, and spinal anæsthesia (spinocaine and ephedrine). Since the routine adoption of intravenous injection of sodium sulphate (isotonic solution) by the drip method (Lawson Dick) Wade considers it safe to carry out bilateral transplantation in all cases. If the catgut wick of Mayo is adopted, ureter catheters are unnecessary. The left ureter, having been found and isolated *below* the pelvic colon, is conducted through the meso-colon on forceps to a position above and to the mesial aspect of the bowel, thus allowing apposition without tension, and the technique of implantation in a situation easier of access with less risk of kinking the ureter. A critical analysis of 54 personal cases of uretero-colic transplantation is given. Wade, in common with the majority of surgeons, prefers to leave in a rectal tube for easy escape of flatus, fæces and urine.

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[*] *Surg. Gyn. Obst.*, 1928, xlvii, 593.

[†] *Proc. Roy. Soc. Med.*, Jan. 1938, xxxi, 277.

(*c*) **Transplantation of the ureter to the skin.**—This operation is indicated where no other form of transplantation can be entertained owing to the pathological state of the ureter or to its reduced length, renal deficiency or a poor general condition. As a means of permanent diversion of the urine it has advantages over the only alternative, nephrostomy. The primary object is to give relief from a chain of burdensome bladder symptoms, such as are common in advanced tuberculosis or malignancy. Relief of intra-renal tension and ascending sepsis may establish such constitutional improvement as to prepare for a later total cystectomy. Iliac implantation is preferred to lumbar, as the ureter is less liable to kinking, the blood supply to the duct is better maintained, drainage apparatus is more satisfactorily applied, and the orifices can be seen and attended to by the patient. The lumbar site is sometimes unavoidable from the shortness of the available ureter.

In the iliac operation the ureter is freed extraperitoneally as low as possible through a muscle-splitting inguino-iliac incision, divided, ligatured, cauterized and the upper end is conducted obliquely through the muscles, some points of suture being placed between them and its outer coats. A large ureteric catheter or fine rubber tube is passed up the ureter into the pelvis of the kidney and the ureter is fixed to the skin one inch from its cut end ; the redundancy is to allow subsequent contraction. It is important to secure a greater length of ureter than the distance to the new opening seems to require, to avoid tension. Sloughing of the last two inches constitutes the main danger of this operation. It is essential to avoid kinks in the ureter's course ; it may therefore be better to conduct it through a separate stab incision.

The ureter tubes are at first drained into bedside receptacles ; subsequently, when the case is ambulatory, into rubber bags held by a belt. It is preferable to preserve tube drainage than to apply rubber caps to entrap the urine. Permanent tubes are well tolerated, and may often be allowed to remain in 4 to 6 weeks without changing. This operation is only likely to be successful when the ureters are dilated, the very cases where ureter implantation to the bowel has been proved unsafe.

OPERATIONS FOR EXPOSURE OF THE SUPRARENAL GLAND

The indication for exploration of one suprarenal gland depends upon the radiographic signs of a tumour. A lumbar approach is generally used. Bilateral exposure is at times essential, for focal signs may be absent, the patient only presenting such abnormalities as hypertrichosis, obesity, virilism, precocious sexual development and hyperpiesis. Although a transperitoneal approach presents opportunities for simultaneous exploration of both sides, removal of tumours, or partial excision in glandular hyperplasia, such operations are very difficult from the front and the lumbar route is much to be preferred. Adson[*] removed the outer half of the suprarenal on each side in six cases, with splanchnic nerve resection and removal of lumbar ganglia through a lumbar approach. The incision corresponds to the usual curved one for kidney exploration, except that it extends higher posteriorly (well over the last rib) and is more limited anteriorly. The last rib is subperiosteally resected and its ligamentous attachments divided, thus allowing, by forceful retraction, a good exposure of the subphrenic fossa. The kidney is displaced downwards or forwards when the adrenal comes to view. The latter organ is friable and must be very gently handled. Adenomata can usually be enucleated readily, but malignant tumours must be formally excised with the surrounding fat and possibly the kidney. If necessary the cœliac ganglion can be exposed and resected with the splanchnic nerves and other sympathetic fibres, the kidney being displaced forwards and inwards. Waltman Walters[†] has used this exposure for the extirpation of suprarenal tumours, and records an interesting series presenting precocious development strikingly improved by removal of the cortical adenomata. L. R. Broster[‡] has used a transthoracic route which he has found easier than a lumbar approach, in spite of pneumothorax, which is almost inevitable.

I have used the Bernard Fey approach (see p. 1889) on four occasions for exploration of the suprarenal, in three of which I removed a gland the seat of a tumour. In one case the gland with tumour, an encapsuled carcinoma, was the size of a clenched fist and it had caused depression of the kidney with rotation, so that its long axis occupied a horizontal position. The approach also provided excellent access for nephropexy (see Plate VIII). The pleura was opened in three of the four cases, but without ill effect.

URETERAL CATHETERIZATION IN THE TREATMENT OF PYELITIS, ESPECIALLY PYELITIS OF PREGNANCY

A single pelvic lavage, or a course spread over a period of months, may be required in obstinate cases of pyelitis, especially of the atonic type. Silver nitrate solution, 1/10,000, or even much stronger solutions, or the colloid silver preparations have been used for the most part. No doubt the passage of the catheter is, in some cases, responsible for the benefits experienced by dilating narrower parts of the channel and, possibly, by exercising an anti-spasmodic effect. It is, however, in the severer types of pyelitis of pregnancy that the more dramatic recoveries have been witnessed. A ureteric catheter left in-dwelling for 24 or 48 hours may bring about a speedy fall in temperature, relief of pain and obvious end of toxic absorption. An initial wash with a silver nitrate solution is generally given, but it is reasonable to suppose that drainage exercises a greater influence than lavage. Excretion urography always shows an advanced state of hydronephrosis in severe types of pyelitis of pregnancy and forcefully indicates the need for drainage ; the rapidity of flow from the ureteric catheter proves increased intrapelvic tension. The wider acceptance of this method of treatment has done much to enable the expectant mother to go to term.

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[*] Adson, Craig and Brown, *Surg. Gyn. Obst.*, 1936, lxii, 314.
[†] *Proc. Staff Meetings Mayo Clinic*, March, 1934, ix, 144.
[‡] *Arch. Surg.*, May, 1937, xxxiv, 761.

URETERAL TRAUMAS AND THEIR TREATMENT

The ureter is injured by :—(1) gunshot wounds, (2) perforation by a calculus, (3) surgical operations, (4) obstetrical complications, and (5) radium therapy.

1. **Gunshot wounds.**—I have come across a few cases in war wounds and these have been recognized by a urinary fistula shown to be unconnected with the bladder by the fact that a coloured solution introduced through a urethral catheter did not appear in the wound discharges. Chromocystoscopy and ureteral catheterization showed the side affected in the 1914-18 war ; to-day excretion urography is the chief aid to diagnosis. Nephrectomy is usually necessary to bring about healing of the fistula.

2. **Perforation by a calculus.**—The condition is rare, and follows ulceration. The calculus escapes into the peri-ureteral connective tissue and causes abscess formation. The ureter may heal spontaneously after drainage of the abscess and removal of the stone, but a fistula is more likely to follow, requiring nephrectomy.

3. **Surgical operations.**—In the course of operations, especially gynæcological, performed deep in the pelvis, one or both ureters may be divided, ligatured, crushed by artery forceps, or the blood supply may be cut off by block dissection for malignant disease, as, for example, in the Wertheim hysterectomy and in perineal excision of the rectum.

4. **Obstetrical complications.**—These may follow either difficult labour, where the ureter sloughs as the result of prolonged pressure of the fœtal head at the pelvic brim, or the inclusion of the bladder base in the faulty application of forceps.

5. **Radium therapy.**—Radium used in the treatment of cervical carcinoma in excessive doses may cause sloughing of the lower ends of the ureters, the outcome of which may be a uretero-vaginal fistula. Smaller dosage can cause a low inflammation, resulting in fibrous thickening, stricture formation and hydronephrosis (T. F. Todd, personal communication). Deranged vascularity may be a sequel to ureters which have been so exposed, and this may account for some failures in the operations of transplantation to the bowel or bladder.

Ligation and other Surgical Traumas of the Ureter

Caulk and Fischer carried out experimental ligature of the ureters in 70 dogs. They found that the blood-nitrogen showed a gradual rise even after the ligature of one ureter. After nephrostomy there was often a further rise for 3 or 4 days followed by a drop to normal.

The ureter is intentionally ligated in the course of operations in the hope that the kidney may atrophy, as in certain cases of partial cystectomy where transplantations are unwarranted. Such ligatures of choice are, however, not always successful ; the ureter may slough and a fistula form, for which there is generally no cure other than nephrectomy. Ligature may be successful in preventing a fistula ; the kidney, however, may not atrophy and a painful hydronephrosis later requires nephrectomy.

Accidental ligature of the ureter may have similar effects. Like crushing or division, it may not be recognized at the time of operation. I removed a huge hydronephrosis 20 years after a hysterectomy ; the patient said she had suffered great pain in her kidney region in the first three weeks after her first operation, but the pain had gradually subsided. It was proved by ureteral catheterization that the ureter was obstructed an inch from the bladder. Accidental bilateral ligature constitutes an urgent problem which comes within the province of the urological surgeon. By the time he is consulted, 36 to 48 hours after the operation, catheterization will have proved unquestionable suppression. If catheterization of the ureters reveals ureteric obstruction 1 to 2 inches above the ureteric orifices, operation is imperative ; its nature will depend upon the capacity of the patient to withstand either a long and complicated abdominal operation or rapid bilateral nephrostomy. According to Leon Harman,* statistics have shown better results from abdominal exploration ; a number of successful cases of deligation are recorded. The previous laparotomy wound is re-opened, or a fresh paramedian incision made to deal with the cause of obstruction. The ureters are dilated, and therefore easily recognized as they cross the pelvic brim. Time will be saved if they are opened and a probe passed down to localize the exact site of obstruction. Obstructing ligatures may be found and removed without fear of hæmorrhage. If the ureters have been divided or crushed, there is little prospect of local repair ; transplantation to the bladder should then be attempted.

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* *Journ. Urol.*, 1923, ix, 151.

If recovery from operative shock does not warrant the risk of what may be a long, difficult operation, double nephrostomy should be rapidly performed. The pelves will be found distended, and nephrostomy is accordingly simplified ; indeed, it may not be necessary to dislocate the kidneys from their beds. Cases were reported by Caulk* and E. J. Judd, where micturition was automatically resumed, evidently due either to absorption of the ligatures or to recovery from bruising. Such a fortunate outcome is not to be expected, and it would be wise to take the earliest opportunity of exploration and repair. It is noteworthy that a bladder deprived of its normal contents is likely to develop severe cystitis, from which ascending sepsis may reduce the ureter to a state unfitted for transplantation. Daily washing with normal saline solution or boracic lotion should therefore be carried out until the normal urine flow is re-established.

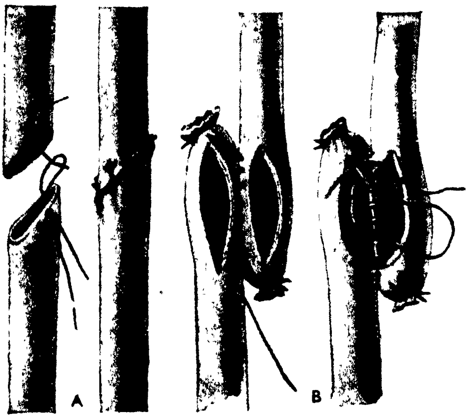

Fig. 971.—Uretero-ureterostomy (after Marion). A, end-to-end ; B, side to side.

When ligature, crushing, or division of the ureter is recognized during the course of an operation it is likely that the main operation has so reduced the patient that a further complicated procedure is not warranted. The surgeon would then be forced to ligate or transplant to the vagina or skin. In more favourable circumstances immediate repair should be attempted. If the ureter is divided some distance from the bladder, uretero-ureteral anastomosis can be carried out, preferably by the end-to-end method (Fig. 971), and such union is made easier if performed on a ureteric catheter : the upper end is passed up to the kidney and the lower end into the bladder, from which it is removed in the course of a day or two by an operating cystoscope or lithotrite. The catheter, while in residence, will assist renal drainage and overcome such obstruction as may be caused at the union by œdema. If the division is too low for anastomosis, probably sufficient length of ureter remains to allow bladder transplantation without undue tension.

In practice the majority of operative ureteral injuries are not recognized during the operation, especially where there is merely a bruising, or possibly nothing more than interference with the blood supply. In these cases leakage of urine takes place into the pelvic cellular tissue, giving rise to an abscess which tracks either to the skin incision or to the vagina. In either case there is an escape of pus followed by a persisting urinary fistula. Spontaneous healing of such a fistula may take place; one or two months should therefore be allowed to give sufficient opportunity for it to close. If it heals, ureter catheterization and intravenous pyelography should be carried out at intervals so that if a stricture forms it may be recognized and treated by regulated dilatation.

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* Caulk and Fischer, *Trans. Amer. Assoc. of G-U Surgs.*, 1915, x, 72.

Where the fistula persists, intravenous pyelography and ureter catheterization must be employed to determine which ureter is injured and at what level. The nature of operative cure of the fistula will be decided upon the data provided; it is seldom possible or wise to perform any operation other than transplantation to the bladder or nephrectomy.

URETERO-URETERAL ANASTOMOSIS

Repair of ureteric injuries in the lower pelvis are seldom sufficiently within reach to permit the complicated technique of uretero-ureteral anastomosis. At higher levels there is every prospect of success. Stenosis is the chief complication to be avoided; to prevent this the following factors should be taken into account: (1) The urine passing down the affected ureter should be as sterile as possible, otherwise ureteritis may be set up at the anastomosis. (2) The anastomosis should be made in such a way that the slight stenosis inevitable after the operation shall not materially diminish the calibre of the ureter. (3) As far as possible, stitches should not be passed through the mucous membrane, as they tend to act as foci for calculi and for micro-organisms. (4) Retroperitoneal drainage to the anastomosis should always be adopted for the first few days, as any slight leakage of urine will set up a diffuse chronic peri-ureteritis with subsequent stricture, or perhaps peri-ureteral abscess with fistula formation.

The *suture material* in all plastic operations on the ureter should be fine catgut 6/0, introduced on atraumatic needles.

The following *types of anastomosis* can be performed, viz., (1) end-to-end, (2) end-in-end, (3) end-to-side or end-in-side, (4) side-to-side. Each of these has been tried either on human beings or on animals.

(1) **End-to-end anastomosis.** (i) *Transverse.*—This was the first type of operation tried; the cut ends are sutured together with interrupted sutures of fine catgut passing through the outer and muscular coats only. There is no loss of length, but a danger of stenosis.

(ii) *Oblique.*—This method was devised by Bovée* and is probably the best in the majority of cases. The upper and lower ends are cut obliquely, and the cut ends united by single interrupted sutures with a few mattress-sutures interposed; the majority of the sutures pass through the outer coats only (Fig. 971, A). This method entails only a small loss of length and stenosis is compensated by the oblique section.

(iii) Perhaps the method where stenosis is least probable is that shown in Fig. 972. Linear incisions are made on opposite sides.

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* *Ann. Surg.*, 1900, xxxii, 165.

of the upper and lower ends. The square extremities are rounded off producing a beak at each end on the side opposite to the linear incision. By suturing the beaked extremities in the apices of the gaps made by the linear incisions, laxness remains, allowing for subsequent contraction without stricture formation.

(2) **End-in-end anastomosis.**—This method, devised by Pozzi,* has given good results in animal experiments. The upper end is brought into the lower, which may be split to increase the calibre. Two fine needles armed with two fine sutures are passed through all the coats of the upper end ; the needles are passed almost side by side from within outwards through the lower end. These sutures being tied, the upper end is invaginated into the lower ; the junction is closed over by interrupted sutures. This method should only be used where the ureter is dilated.

(3) **End-in-side, or lateral implantation.** — This method was devised by Van Hook,† and is somewhat similar to the end-in-end method, except that the upper end is invaginated into an incision in the side of the lower, the kidney end of the lower part is ligatured, and the lower end of the upper is slit for a short distance. This method requires more length of ureter than the others but, where there is a sufficiency, gives good results.

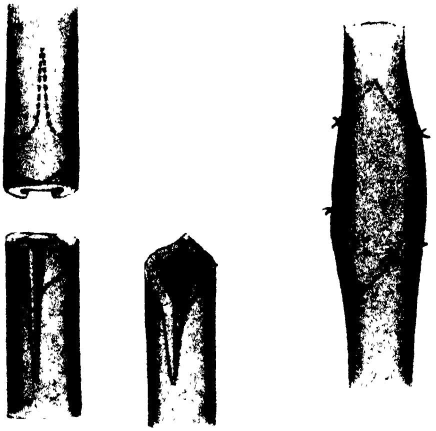

Fig. 972.—Uretero-ureterostomy (after Marion).

The vertical incisions and bevelling allow, when suturing is completed as shown, a larger lumen than the rest of the ureter.

(4) **Side-to-side anastomosis.**—This method is similar to the operations for lateral intestinal anastomosis ; it requires more ureter than is usually available (Fig. 971, B).

Results.—Alkane‡ collected 60 cases of ureteral anastomosis published since 1886. He found 43 were cured, 9 were cured after a temporary fistula, and 8 died. The best results followed end-to-end suture with invagination. In every case which survived there was a slight degree of hydro-ureter or hydro-nephrosis. Petersen,§ in studying 72 cases of ureteral anastomosis, found a mortality of 5.5 per cent. directly attributed to the operation. In his report the end-in-end union appeared to be the method of choice, from its easy accomplishment and minimum sacrifice of ureter.

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* XIX Cong. de Chir., Paris, 1906, p. 188.
† *Journ. Amer. Assoc.*, 1893, xx, 911, 965.
‡ *Folia Urologica*, 1908, iii, 280.
§ *Surgn. Gyn. Obst.*, Aug., 1920, xxxi, 132.

CHAPTER XLII

OPERATIONS ON THE BLADDER

By R. OGIER WARD

Anatomical considerations.—In the adult, the bladder, when empty or partially distended, lies within the bony pelvis. When, however, it is over-distended a large area of its anterior surface lies immediately behind the abdominal wall. In the infant and young child, the bladder occupies a higher level, and even when empty the upper part of it lies above the bony pelvis. After the skin over the bladder has been divided, the subcutaneous fat is exposed, its depth varying greatly in different subjects. When this has been incised and retracted, the linea alba is seen in the middle line with the anterior rectus sheath on either side of it. If the latter is opened just to one side of the middle line, the lower part of the fibres of the pyramidalis abdominis muscle is seen running upwards and inwards towards the middle line. This muscle varies considerably in size in different individuals and may be present on only one side, absent on both sides, or, very occasionally, double on one or both sides. Above and outside it are the vertical fibres of the rectus abdominis muscle. Below the semilunar fold of Douglas the lower fourth of the rectus muscle has no posterior sheath, and rests directly upon the transversalis fascia. Immediately deep to this, in the upper part of such an incision, is the peritoneum where it is reflected from the superior surface of the bladder. If the incision is carried through the transversalis fascia, and at the same time the peritoneum is pulled upwards, the fatty tissue of the prevesical space is entered. In elderly subjects condensations of fibrous tissue are not infrequently met with here and need to be divided before the anterior wall of the bladder itself is revealed. The latter is recognized by its colour, which is a shade between pink and grey, by the fasciculated appearance of its outer muscular coat, and by the tortuous veins upon its surface. The thickness of the muscular wall of the bladder varies widely in different subjects, when empty being usually about ½ cm. ; when distended the wall often becomes extremely thin. In disease which causes obstruction to the bladder outlet, its wall is often, though by no means always, hypertrophied, particularly if inflammation exists, and it may not infrequently be as thick as 2 cm.

At the apex of the bladder, where the broadened lower end of the urachus leaves it, the peritoneum is most closely adherent. Elsewhere, and particularly on the lateral aspects, it is very loosely attached, and under normal conditions the bladder is easily freed from its surroundings when the peritoneum has been dissected from its upper surface, but when inflammation has occurred, and particularly if this is of long standing, the peritoneum is more firmly attached. Occasionally it may be firmly adherent to the back of the symphysis pubis.

Anæsthesia.—The choice of anæsthetic in bladder operations naturally varies with the extent of the operation and the condition of the patient. Cystoscopy may be performed without anæsthesia ; it always causes the patient discomfort and frequently pain. Local anæsthesia has been employed with some measure of success, using 5 per cent. novocain, or percaine, or Ryall's solution :—

Cocaine hydrochloride	0.5 grm.
Sodium bicarbonate	0.5 ,,
Chlorbutol	0.25 ,,
Distilled water	100 c.c.

In rare instances death has followed the use of percaine and cocaine in the urethra. Novocain may be employed without danger. Ten cubic centimetres of the solution are introduced into the anterior urethra, using a syringe with a suitable nozzle such as that illustrated in Fig. 973. The penis is compressed at the end between the thumb and forefinger and the lotion is then milked along the canal through the compressor into the prostatic urethra. Another 10 c.c. of the solution is introduced and the penis is clamped just below the glans with a Thomson-Walker clamp (Fig. 974). Ten minutes is allowed to elapse ; the efficacy of the anæsthetic is greatly diminished if it is not allowed this length of time to act. The instillation anæsthetises the mucous membrane, but when the canal is straightened by the cystoscope, a considerable strain is put upon the triangular ligament and the suspensory ligament of the penis, which sometimes causes much discomfort.

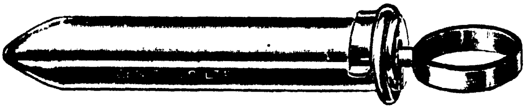

Fig. 973.—Ogier Ward's anterior urethra syringe.

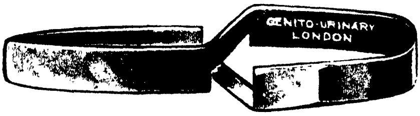

Fig. 974.—Thomson-Walker's penis clamp for local anæsthesia.

A sacral block is simple and usually effective and the patient need not be confined to bed after it. For this purpose a needle 3–4 ins. long, a 20 c.c. syringe and 30 c.c. of 1 per cent. novocain or percaine are required. With the patient in the prone position, the boundaries of the inferior outlet of the sacral canal are identified. These are usually felt easily, and consist of the tubercle forming the spine of the fourth sacral segment above and the cornua, one on each side of the middle line, below. The point of the needle is inserted midway between the two cornua, and a small amount of anæsthetic is introduced. The needle is pushed in an upward direction so as to enter the sacral canal, a little anæsthetic being continuously injected. After entering the canal, the needle is passed until it is felt to impinge on the bony anterior wall, usually a distance of some three inches. The remainder of the 30 c.c. of solution is now slowly injected. It is always wise before doing this to withdraw the piston of the syringe to make sure that the point of the needle is not in a vein. In ten minutes anæsthesia will be adequate.

A low spinal anæsthesia, using preferably 0.3–0.4 c.c. of percaine, is very useful in performing transurethral operations on the bladder, and spinal anæsthesia extending as high as the umbilicus is valuable where easy access to the bladder is essential, as, for instance, in the excision of a vesical diverticulum. It is always advisable for the patient to remain in bed for 48 hours after this anæsthetic.

For suprapubic cystotomy inhalation anæsthesia is probably most satisfactory in the majority of cases. Since it is usually very important that diuresis should be established as soon after the operation as possible, premedication must be considered very carefully.

In a certain number of cases, the general condition and renal function of the patient are such that an extensive anæsthesia in any form is definitely contra-indicated. Cystotomy should then be done under local anæsthesia. The bladder should always be well distended with fluid—16 oz. if this amount can be tolerated. Half per cent. novocain or percaine is used, and the 10th to 12th thoracic nerves are blocked at the outer border of the rectus abdominis on each side. A point is taken just below the level of the umbilicus in the line of the outer border of the rectus. A needle is inserted and is felt to penetrate the rectus sheath. The solution is gradually injected and the point of the needle is guided downwards for some two to three inches. In all, 20 c.c. should be introduced on each side. The subcutaneous layer in the suprapubic region, in the line and for rather more than the length of the incision, are infiltrated, as is the muscular layer. As a rule anæsthesia is established in five minutes. It is occasionally necessary to introduce more anæsthetic after the muscles have been exposed.

CYSTOTOMY AND BLADDER DRAINAGE

Perineal cystotomy as a method of primary bladder drainage is not performed at the present day, though the bladder is drained through this route in certain operations for stricture of the urethra and after perineal prostatectomy. Details will be found in the sections dealing with these procedures.

SUPRA-PUBIC CYSTOTOMY

Indications.—This operation is the first step in draining the bladder, in the removal of stone and foreign bodies, the excision of growths and diverticula, or in the approach to any other condition affecting the bladder wall or its cavity; also in suprapubic operations on the prostate.

Technique.—The pubic and scrotal region is shaved and prepared for operation, and the patient anæsthetized. A catheter is passed and the bladder distended with warm sterile water or antiseptic solution. If the urine be foul, the bladder is irrigated until the fluid returns clear. The amount of distension will vary in different cases. When the bladder is not spastic, about 12 oz. may be introduced, though 8 oz. is usually sufficient. In a spastic bladder it may only be possible to introduce a much smaller amount of fluid; if the fluid is run in very slowly, however, the bladder will often tolerate more.

The catheter may be left in the urethra, the open end being plugged with a spigot, or it can be removed. Sterilized towels are arranged so as to leave the space between the pubes and the umbilicus uncovered. The surgeon stands on the left of the patient, and the assistant opposite to him. The mid-line incision commences at the upper border of the symphysis pubis and passes upwards. The length and position of the incision vary with the object of the cystotomy and the size and build of the patient. An incision of 2 in. will often suffice to introduce a drainage-tube into the bladder. For operation on growths and for open prostatectomy the incision will be about 4 in. or the full extent from pubes to umbilicus if this be short. The rectus sheath is incised to the full extent of the wound, and the pyramidalis muscles appear at the lower and the recti at the upper part of the wound. The division between the recti should be sought, though no harm is done if the approach is made between the fibres of one of them, provided it is fairly close to the middle line. The tendinous line between the pyramidalis muscles usually requires division. Retractors are now introduced, and the transversalis fascia covering the front of the bladder is divided immediately above the symphysis pubis. The prevesical fat and condensations of fibrous tissue in it, which are often met with, should be dissected by transverse cuts; the muscle fibres and veins on the anterior surface of the bladder then become clearly visible. The peritoneum is not usually seen at this stage, particularly if the abdominal incision is a small one, and care must be taken not to begin by seeking for the bladder in the upper part of the wound. The bladder-wall is picked up with tissue forceps on each side. The assistant, with a piece of gauze, presses upwards and backwards upon the upper part of the bladder to shield the peritoneum. A scalpel is now thrust through the bladder-wall in a direction vertically downwards, and the cut at once extended to a suitable length towards the symphysis pubis. The fluid which flows out of the bladder is removed by a suction apparatus, by swabbing, or by a Thomson-Walker tray. It is essential to cut through all the coats uniformly, and unless the anterior surface is well cleaned before it is incised, this may be difficult to achieve after it has once been punctured and become deflated. The edges of the incision are next picked up with tissue forceps, and if any further extension of the operation is intended, a stay suture should be passed on either side, each being held in a pressure forceps. To enlarge the opening, a finger is introduced and the bladder hooked up into the wound. The peritoneum is now usually seen, and is freed by small transverse snips with blunt-pointed scissors, or by blunt dissection, and is pushed up towards the abdominal cavity. When this has been done the cystotomy opening can be safely enlarged. This will be necessary in any operation other than drainage.

It is not essential to distend the bladder before cystotomy, though if sepsis is present preliminary irrigation should always be given. If the bladder is not distended the patient should be in the Trendelenburg position, and the incision should not be less than 3 in. long. Dissection must be deliberate down to the bladder wall, particular care being taken to strip the peritoneum upwards. The bladder is then picked up at two points near the upper part of its anterior wall with tissue forceps, or sutures may be introduced for the same purpose. The wall of the bladder should then be carefully incised until the lumen is exposed, when the edges of the incision are secured with tissue forceps.

Modifications.—A transverse skin-incision may be used. This will be described under the technique of prostatectomy by the method of Harris (*see* p. 2065). Instead of incising the bladder vertically, the incision may be made at any part of the wall and in any direction. Thus, in removing a growth from the bladder, the incision is planned so that the resection may be carried out and the bladder opened in the first instance without cutting into the growth. In exceptional cases it may be necessary to divide one rectus muscle transversely. It is, however, much better to increase the exposure by prolonging the vertical incision upwards, for the repair of such a divided muscle by sutures is difficult owing to the absence of any posterior sheath below the semilunar fold of Douglas, a fact which makes sutures apt to cut out; also, if any sepsis occurs, the liability to hernia is greatly increased.

Difficulties of the operation.—**Injuries to the peritoneum.**—The peritoneum may be inadvertently opened when the bladder-wall is incised. The accident is usually due to want of care in freeing and pushing it up out of the way. The smaller the abdominal incision the greater is the need of caution, particularly if the bladder has not been previously distended. In exceptional cases the peritoneum may be densely adherent to the bladder and even fixed to the symphysis pubis, much careful dissection being necessary to free it. *In secondary operations upon the bladder* the risk is always greater, particularly if a suprapubic fistula remains. In such cases the upper part of the abdominal incision should receive first attention, as the tissues here will be more normal. The dissection is carried down on either side of the scar of the original cystotomy opening until this is free laterally and below. If a fistula is present this is then excised. Should the peritoneum be opened, a finger is introduced into the bladder which has been mobilized, and the peritoneum can then usually be freed sufficiently to ensure more easy repair by a continuous suture, and its escape from further injury during the remainder of the operation.

In such circumstances no harm will result, even when sepsis is present, the danger being not the accidental opening of the peritoneal cavity, but the failure to recognize that this has happened. If sutures tend to cut out, it is sometimes quicker to tie a ligature round the tear while the margins are held up with pressure forceps. The exposure of the bladder is sometimes facilitated by the Trendelenburg position, and this is particularly useful when the patient is fat.

Hæmorrhage.—There are often big vessels on the anterior wall of the bladder, and these occasionally cause troublesome bleeding. For this reason it is always desirable to expose the bladder wall freely before incising it, and to ligature any arteries and veins which have to be divided. The latter may be secured by under-running them.

Immediate suture after cystotomy.—Immediate suture of the bladder-wall is the ideal method of treatment, but it is not always expedient.

Contra-indications. *Obstruction.*—After opening the bladder in a case of obstruction it may be found impossible to remove the cause, *e.g.* malignant disease of the prostate. In such a case an attempt to close the bladder-wound will fail. Permanent suprapubic drainage will probably be necessary. On the other hand, it may be possible to remove the obstruction but inexpedient to proceed to the radical operation at once. Thus, in some cases of enlargement of the prostate, temporary drainage is indicated preparatory to the radical operation.

Sepsis.—When cystitis exists, or when there are septic changes in the kidneys, immediate suture of the bladder is unwise. Obstruction and sepsis frequently combine to contra-indicate immediate suture of the cystotomy wound.

Hæmorrhage.—After the removal of bladder growths it is wise to place a drain in the bladder, unless the surgeon is convinced that all bleeding has ceased and will not recur. If there is oozing, drainage is imperative.

Closure of the bladder-wound.—The cases most favourable for immediate closure of the bladder-wound are those of cystotomy performed for aseptic calculi or for foreign bodies, and of operation for papilloma where the bleeding has been effectually controlled. Some surgeons close the bladder in selected cases of suprapubic prostatectomy. The bladder-wound is closed as follows: The edges of the abdominal wound are drawn well back with retractors and the bladder-wall is brought into the abdominal wound by traction on the stay-sutures. The suture material is No. 1 catgut ; only the plain variety should be used for operations within the urinary tract as sutures which are not readily absorbable may act as nuclei for the formation of calculi. Either interrupted or continuous sutures are used. The first row passes through the bladder muscles and the mucous membrane, with the object of securing apposition and arresting hæmorrhage. A second row may be placed in Lembert fashion over the first. A small drainage-tube is introduced through the abdominal wall down to the sutured bladder wound. The abdominal wound is closed by sutures as described on p. 1986. A catheter is placed in the urethra and fixed in position (*see* p. 1988). In the female one of the self-retaining varieties is employed.

After-treatment.—When the bladder has been completely closed, the catheter is retained in the urethra for ten days and the urine allowed to drain into a bottle between the patient's thighs. A careful watch is kept to prevent the catheter becoming blocked with clot, and with this object in view 2 to 3 oz. of oxycyanide solution, 1 : 6000, should be injected when necessary, and at least twice in the 24 hours. It is better to avoid washing the bladder, as distension may start bleeding or may open the sutured cystotomy wound, but should the catheter block it must be gently syringed to clear the lumen. The prevesical tube is removed in 2–4 days. If copious bleeding and intravesical clotting occur, the catheter will be useless. In these cases the bladder usually fills with clot, so that it can be felt above the pubes. It is wise in such a case to re-open the suprapubic wound without delay, clear out the clots, irrigate the bladder through the catheter with a copious stream of warm oxycyanide of mercury, 1 : 6000, at a temperature of 90° to 100° F. (some surgeons have the lotion as hot as 120° F. with the object of promoting hæmostasis), and place a large drainage-tube in the bladder-wound.

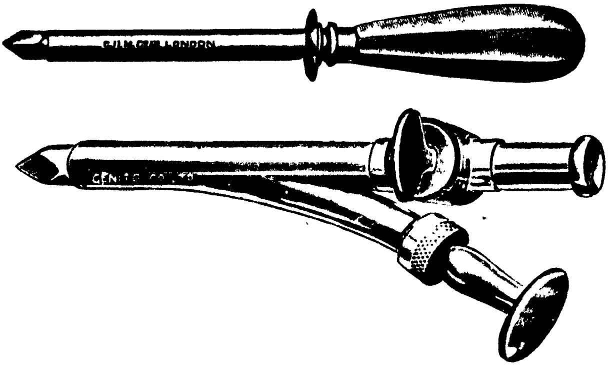

Fig. 975.—Morson's trocar for cystotomy (above).
Kidd's trocar for cystotomy (below).

SUPRAPUBIC DRAINAGE

Temporary suprapubic drainage.—This is practised after the majority of suprapubic operations.

Indications.—Retention of urine, cystitis or renal insufficiency which does not respond to treatment by indwelling catheter or other methods; and after transvesical operations for stone or growth, or enlargement of the prostate.

Technique.—Morson's or Kidd's cystotomy trocar (Fig. 975) affords means of draining the bladder through the smallest possible abdominal incision. The bladder is distended with 12 or more ounces of fluid, and a vertical midline incision is made about two inches above the symphysis pubis for a length of 1 in. through the skin and the anterior rectus sheath. The trocar and cannula are then plunged not quite vertically but slightly downwards into the bladder. When the trocar is withdrawn the lotion rushes out (unless Kidd's pattern is used), but before much of it has escaped the end is closed with a finger, and a Malécot tube (28 Charrière, 17 English) on an introducer is passed through the cannula into the bladder, the cannula being withdrawn over it. This procedure should not be used in the presence of a large intravesical projection of the prostate, as there is a risk of injuring this and causing severe hæmorrhage. Nor should it be employed if the bladder has previously been opened, because in such cases the peritoneum will almost certainly lie in front of the bladder, even when it is distended. The method is not without risk, as vessels on the anterior surface of the bladder may be opened by the point or edges of the trocar. In introducing the latter it is necessary to make a forceful stab, as otherwise the bladder, particularly if it is thick-walled, may be only pricked and will then empty itself behind the abdominal wall, making it impossible to introduce a tube without further dissection.

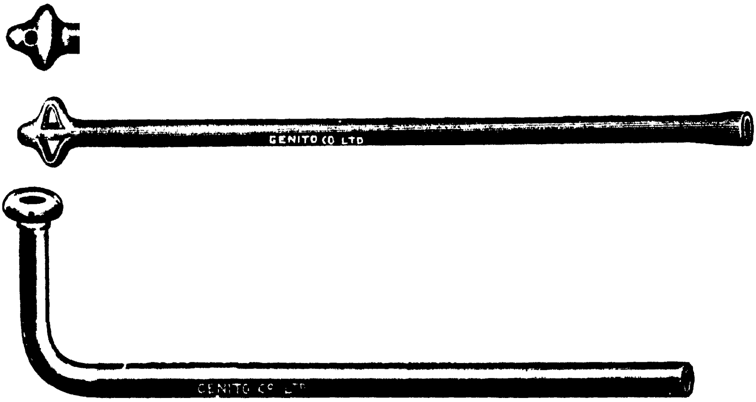

Fig. 976.—Self-retaining tubes.
A. De Pezzer. B. Malécot. C. Winsbury-White.

If suprapubic drainage is to be efficient when hæmorrhage is in progress, it must be free, and in such cases a rubber tube with a diameter of ¾ in. or even 1 in. should be used. A suitable type is Marion's tube (Fig. 1003, p. 2054) which has a convenient arrangement for irrigation. It should be of sufficient length to reach into the bladder but not to press upon the base and it should project slightly above the skin-surface. Two large lateral openings are provided near the vesical end. The tube emerges from the bladder at the upper part of the cystotomy wound. The bladder wound is sutured up to and around the tube, and the former contracts to lie round the tube like a funnel. The tube is held in place by a silkworm-gut suture through the skin. Through a large tube such as this clots are readily removed with forceps, and the bladder can be flushed with an adequate stream of antiseptic fluid.

Where, however, there is no question of hæmorrhage and the object of the drainage is to prevent any possibility of distension or to drain an infected bladder, a tube with a smaller calibre will suffice, and for this purpose one of the varieties of self-retaining tubes, de Pezzer, Malécot, or Winsbury-White (Fig. 976), is suitable and may be used either straight or angled in sizes varying with the conditions from 24 to 36 Charrière (14–22 English). (See note on p. 2044.)

Closure of the abdominal wall after cystotomy.—In closing the abdominal wall it is desirable to place a small piece of tubing or corrugated rubber below the bladder-tube to drain the prevesical region. As the recti have no posterior sheaths, it is necessary to maintain them in apposition by interrupted sutures. These may pass through the muscles only, or better should first transfix the anterior sheath and then the muscle beneath, next taking up the muscle of the opposite side and then its sheath. These stitches are left loose until sutures alternating with them have been inserted through the sheath only and tied. After this the former are tied, but not too tightly. The skin is closed with salmon-gut or Michel clips. Care must be taken that the latter do not become detached and enter the bladder. It is never necessary to bring the bladder up to the surface and stitch it to the skin, as has sometimes been recommended.

Methods of draining away the urine.—1. If one of the three types of self-retaining suprapubic drainage tubes already mentioned is used, collection may be made either into a glass urinal in the bed, or into a bottle slung from the bed-frame or standing beneath it. In the latter case it is very important that the weight of the extension tubing should not be allowed to pull upon the bladder-tube. It should, therefore, be strapped to the patient's thigh in such a way that movement of the limb will not produce an undue pull, or it may be loosely fixed by a safety-pin to the sheet at the side of the bed. In either case it is important that when the patient is moved this area should be fully uncovered, so that no unexpected jerk may drag on the tube or even pull it out of the bladder. If this should occur, it not infrequently happens that the expanded end of the tube does not come completely out of the abdomen, but remains behind the recti, and for this reason the displacement may not be observed. As a many-tailed bandage often slips up a patient's body, no folds should be passed beneath such a tube ; all should lie external to it.

(2) *Overflow apparatus.*—Hamilton Irving's box (Fig. 977) is made of celluloid or of metal, and consists of a cup having a small rim and a perforated cover which can be removed like a lid. The cup

is fastened in place with its rim next the skin by means of an elastic strap passing round the abdomen ; a tendency to slip upwards may be counteracted by tapes passing from the lower end round the perineum and held to the abdominal band, though this is usually unnecessary. The urine escapes by two outlets, one on each side of the lower end of the apparatus, and passes through rubber tubing to a suitable bottle between the patient's thighs ; or long tubes may be placed and carried under the thighs into receptacles under the bed. Often only one tube will be used, the other opening being plugged with a cork. A useful modification is that of S. MacDonald (Fig. 978). This has the advantage that, owing to its shape and lightness, less traction is made upon the wound. The Hamilton Irving appliance has the disadvantage that the cystostomy almost always gets dragged upon, and the skin-opening gapes. Whichever apparatus is used, the rule should be never to strap it on more tightly than is necessary to prevent leakage. It should always be removed twice in the 24 hours for a period of one hour. The skin covered by it can usefully be treated with a mixture of zinc oxide ointment and castor oil. If the box is made of metal it is sterilized by boiling ; if of celluloid it is carefully cleansed with soap and water and then soaked in 1 : 20 carbolic, which must be washed off before it is re-applied.

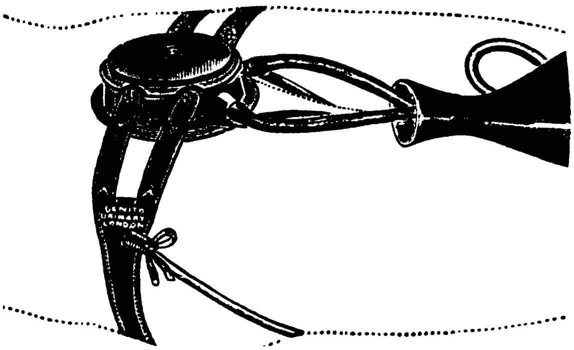

Fig. 977.—Hamilton Irving's box.

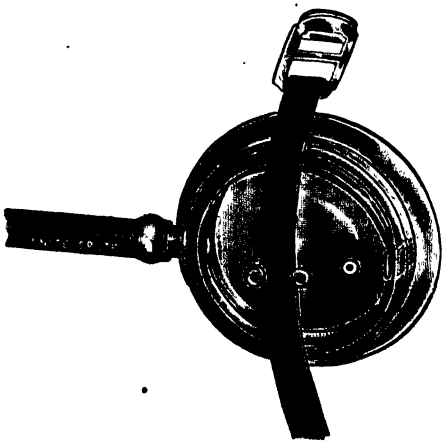

Fig. 978.—MacDonald's box.

Often it is not thought desirable to apply either apparatus immediately after cystostomy. In this case, a gauze dressing with large pieces of cellulose wadding is much more efficacious in absorbing urine than ordinary cotton-wool.

(3) *Exhaust methods.*—A Sprengel water-pump, electric pump or drip suction may be used to maintain suction. In this case a reservoir for the collection of fluid is placed between the pump and the patient.

Continuous irrigation after cystotomy.—When the bladder is drained for sepsis, or an operation has been performed on a septic bladder, or hæmorrhage is profuse and persistent after operation, continuous irrigation should be installed. The best arrangement is to pass and *tie in a catheter.* If this is of rubber, the flute-tipped pattern (size about 20 Charrière, 11 English) (Fig. 1017, p. 2090) is very useful, and can be attached at the external meatus by a strip of elastoplast twisted round it and passing up either side of the penis. If a silk-web Coudé catheter (size about 18 Charrière, 10 English) is used it is attached by two tapes tied round it at the external meatus, with the four ends of these lying at equal intervals round the penis to which they are fixed by elastoplast. Whichever instrument is used, it should be disposed so that both the terminal openings lie just within the internal meatus. The catheter is connected by rubber tubing either to an irrigator on a stand, which may be covered with a blanket and kept hot by a hot-water bottle or electrically, or to a large thermos flask. A drip-feed and screw-clip control are necessary. If a suprapubic tube of the de Pezzer or similar type is used, the urine is easily drained away through this. If a large short bladder-tube is in position, then an Irving or MacDonald apparatus is applied. The irrigating lotion may be oxycyanide of mercury solution, 1 : 6,000 to 1 : 8,000, silver nitrate solution, 1 : 10,000 to 1 : 20,000, or any other dilute antiseptic. The temperature when it reaches the bladder should be between 90° and 105° F. Continuous irrigation can be used for weeks on end if necessary. Tidal drainage by Munro's method (or a modification) is sometimes useful, but must be very carefully supervised

Permanent suprapubic drainage—Permanent suprapubic drainage may be required in bladder or prostatic disease and occasionally in other conditions. The operation is in most particulars the same as that for temporary drainage, and although it can be carried out through a very small incision, one of less than 2 in. is not recommended. It is important that there should be a long sinus between the skin and the opening in the bladder. The walls of this then fit tightly against the tube and prevent leakage of urine. For this reason the tube should not be brought out less than two inches above the symphysis pubis. The tube may be either a de Pezzer or Malécot ; the former usually makes the more water-tight joint. A large one (size 36 Charrière, 22 English) may be used at the time of the operation, to be replaced subsequently by a smaller one ; 28 Charrière, 17 English size will be found suited to most cases for prolonged use. Either type can be changed when necessary, a fresh one being introduced by stretching it tightly upon a metal stylet and lubricating its end. Such tubes are suitable when the urine is fairly clean. They can be conveniently cut short, a spigot or a vulcanite tap being used to close the end, except when emptying the bladder. If the urine is alkaline and deposits phosphates, or if it is very septic, or if leakage occurs, as it sometimes does, then the better method is to employ a straight rubber tube of 28 or 30 Charrière size (English 17 or 18), having two lateral eyes close to the end, which is rounded and smooth. This is arranged so that about an inch of it lies within the bladder cavity. At the skin-surface it passes through a rubber shield which is fastened to the waist by an elastic belt. If the opening of the sinus is too low, it will be found that when the patient sits down the belt is pressed up and displaces the tube, and leakage results. This is another reason for performing high cystostomy. Such a tube cannot be plugged except for such short periods as when taking a bath, but must be allowed to drain continuously into some receptacle, which is usually a rubber urinal worn suspended from the belt and attached to the leg (Fig. 979).

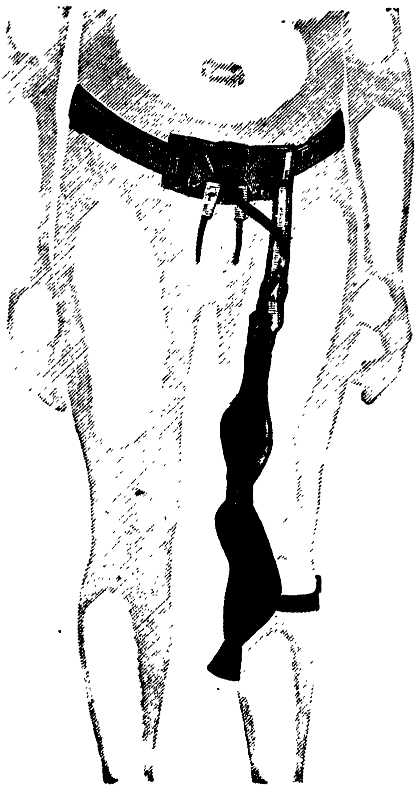

Fig. 979.—Permanent suprapubic drainage apparatus.

PERINEAL DRAINAGE

When cystitis complicates urethral or prostatic disease for which a perineal operation is performed, the bladder may be drained by the introduction of a perineal tube (*see* the section on the Urethra : External Urethrotomy, p. 2116). The best form of drain is a flexible thick-walled rubber tube with a terminal opening ; the edges of the opening are smooth and rounded (Fig. 980). The tube is introduced through the prostatic urethra, with the opening lying just inside the bladder. Its position is tested by injecting a syringeful of lotion into the bladder, withdrawing the tube until it ceases to flow, and then pushing it in

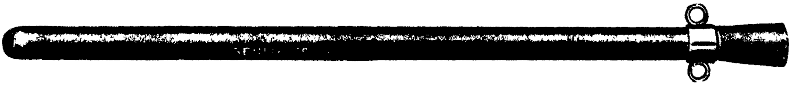

Fig. 980.—Perineal drainage tube and ring.

until the flow recommences. A silkworm-gut suture is passed through each lip of the perineal wound and through the eyes of the metal ring round the tube, to hold it in position. To the tube is attached a length of rubber tubing, either short, and passing to a urine-bottle between the patient's thighs, or long, and passing beneath one thigh into a receptacle containing antiseptic fluid beneath the bed. The tubing is fixed at the side of the bed by means of a loop of tape and a safety-pin. Drainage by this method may be maintained for three to seven days, but this route is not suitable for permanent drainage.

OPERATION FOR INJURIES OF THE BLADDER

In civil practice gunshot or other perforating wounds sometimes require operative treatment, but the need for this is most often met with in the case of **traumatic rupture of the bladder** due to direct injury ; in some instances it may be produced by a splinter of a fractured bone. In the majority of such cases the opening is in the *anterior extra-peritoneal wall* of the bladder. In a typical case there is inability to pass urine, or hæmaturia, only a small quantity of urine being withdrawn on catheterization, and presently an increasing swelling appears immediately above the symphysis pubis. Operation should be performed as soon as the shock—often present in severe degree—permits. In some instances operation may be preceded by a cystoscopy, which will prove useful in cases of doubt and will give accurate information on the position of the rupture. A flushing cystoscope should be used and the bladder gradually distended under vision, with normal-saline irrigation. If cystoscopy is employed, it should be done under anæsthesia in a theatre, with great caution and all arrangements made to proceed at once to operation. A midline subumbilical incision, not opening the peritoneum, is used, and blood-stained urine, often in large amounts, is evacuated. If the bladder-wall is not only ruptured but also lacerated, cystostomy must always be performed and the prevesical space drained. Whenever possible, however, primary closure of the bladder-wall should be undertaken. A 22 Charrière catheter (12 English), or larger if the urethra permits, preferably of the flute-tip pattern, should be introduced and fixed carefully in position. A continuous suture of No. 1 catgut is then used to secure accurate apposition of the edges of the tear, and is invaginated with overlying sutures which may be continuous or interrupted. When this is completed the efficacy of the suture-line can be tested by syringing through the catheter, a procedure which will also serve to determine the presence of any other hole in the bladder-wall, a possibility which in these cases must not be overlooked, and the peritoneum may have to be opened to exclude it. The abdominal wall is closed except for a tube draining the prevesical space.

When rupture of the bladder is associated with fracture or disruption of the pelvis, for which treatment in plaster may presently be necessary, it is particularly desirable to avoid a urinary fistula, and primary suture of the bladder should be undertaken whenever practicable, having due regard to the extent of injury to the bladder and the patient's general condition.

When the rupture is *intra-peritoneal* no abdominal tumour develops. Operative treatment should be undertaken without waiting for signs of free fluid in the peritoneal cavity. The patient is put in the Trendelenburg position, and the peritoneal cavity is opened through a midline incision. When the tear in the bladder has been repaired with a double line of sutures, a catheter should be placed in position through the urethra. After the bladder has been washed through the catheter to prove the suture-line to be sound, the abdominal wall is closed except for a small tube to drain the lowest part of the incision. The catheter is left in position for ten days. Should the search for the laceration be unsuccessful or the patient's condition critical, it may be advisable to be content with bladder drainage. It must not be forgotten that an intraperitoneal and an extraperitoneal rupture may co-exist and that in injury to the perineum severe enough to cause rupture of the urethra there may also be a tear of the vesical neck or some other part of the bladder. If this is suspected, exploration of the bladder and cystostomy is the appropriate treatment.

OPERATIVE TREATMENT FOR THE REMOVAL OF THE ECTOPIC BLADDER

Various operative procedures have been employed with the object of reconstructing the bladder, but most have proved failures owing to the difficulty of providing a competent sphincter muscle. Marion, however, asserts that he effects this in children of both sexes by his method of reconstruction of the urethra (*see* p. 2038) which is followed by the freeing, reformation, and closure of the bladder.* Most surgeons prefer transplantation of the ureters into the colon, since this provides a cure for the incontinence of urine, and the mortality for this operation is not unduly high (*see* p. 1966). The ureteric transplantations are usually performed at two separate operations, which should be undertaken at as early an age as possible, though the very young should not be treated, since intelligent co-operation of the patient is required in learning to control the activities of the bowel. About six months after the second ureter has been transplanted, or whenever the patient is judged to be fully recovered from its effects, useful indications of which are good sphincter control, gain of weight, and absence of thirst, the ectopic bladder should be excised. This usually proves difficult, for the tissues are highly vascular and bleeding is considerable. Moreover, the symphysis pubis is often widely separated, and on this account difficulty is experienced in bringing together the recti muscles. An incision is made outside the area of the mucous membrane, and this is dissected free, care being taken to avoid opening the peritoneum. When this has been completed, there is, in the lower part of the wound, a cavity extending into the bottom of the pelvis. The sheaths of the recti muscles are opened to allow their being brought together by interrupted sutures. The anterior layer of the sheaths are then sutured. There usually remains, however, a gap between the muscles immediately above the symphysis pubis ; this requires drainage by a tube, and packing may be necessary for the arrest of hæmorrhage. It is unnecessary to attempt any closure of the gap between the two pubic bones.*

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* 3rd. Ed., vol. 2, p. 1060.

OPERATIONS FOR VESICAL CALCULUS

Preliminary considerations.—Before undertaking the treatment of stone in the bladder the case requires thorough investigation. This should be directed in the first instance to the local condition. X-rays of the bladder area will in most cases show the size and number of the calculi. It must, however, be remembered that a pure uric-acid calculus is translucent to X-rays, and that if the photographs are not of good quality other soft stones may escape notice. If any outlying stone is seen, the possibility that it is lying in a diverticulum must be borne in mind. An X-ray will in most cases demonstrate a foreign body if a calculus has formed around it. Cystoscopy gives further information on all these points. Because severe cystitis is often present it may be necessary to wash the bladder for long periods in order to obtain an adequate view, and a flushing cystoscope is recommended. This examination will also reveal complications such as enlargement of the prostate, vesical neoplasms, or diverticula. X-rays should be taken of the kidneys and ureters. Excretion urography should be employed if there is doubt of the existence of calculi or other pathological processes in these organs. Renal function should be investigated by the usual tests.

Removal of stones through urethral instruments.—Very small stones may conveniently be aspirated through a urethral instrument such as the cannula of a Bigelow's evacuator, or the sheath of a resectotome. The bladder is moderately distended. The objective of the telescope, and thus the fenestrum of the sheath, is moved until it is brought into close contact with the calculus. To the outflow tap a piece of tubing has been joined which should be sufficiently long (about 3 ft.) to establish powerful hydrostatic suction, and when the outflow tap is opened the stone is thereby drawn into the end of the sheath, from which the telescope is withdrawn slightly to make room for it. While the fluid is still running out, the whole instrument is removed, the stone being inside it.

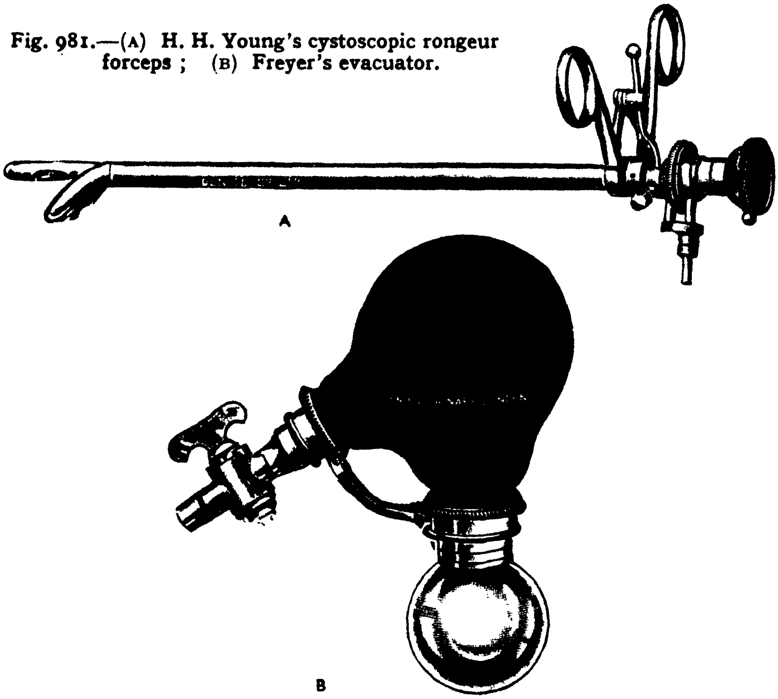
Grab forceps can be introduced through the same type of instrument, and very small calculi can be thus picked up under vision through the telescope and drawn out through the sheath. Special instruments are made through which some larger calculi can be removed. Small stones can also be aspirated from the bladder by means of a Bigelow's or Freyer's evacuator (Fig. 981B).

W. Walters, *Amer. Journ. Surg.*, 1934, xxiv, 776 (26 cases with 1 death).

Litholapaxy

Most vesical calculi are best dealt with by litholapaxy, but there are certain difficulties connected with this method and some selection of cases is essential. It is an operation of extreme delicacy and skill, and requires experience in urethral manipulation and in the use of the lithotrite. Skilfully employed, it will save the patient some weeks of the convalescence which would follow a cutting operation, but if the surgeon does not possess the necessary skill and experience, lithotomy is the safer operation.

Fig. 981.—(A) H. H. Young's cystoscopic rongeur forceps ; (B) Freyer's evacuator.



Difficulties.—Difficulties depend on the stone and on the condition of the urethra, prostate, bladder, and kidneys.

1. **The calculus.**—(*a*) Very *large* calculi are better treated by lithotomy. The grasp of a large lithotrite is up to about 2 in., and when the stone exceeds this in diameter litholapaxy should not be attempted. One diameter of the stone may be smaller, and by manipulation this diameter may be found, and the stone crushed, when at the first attempt it appeared too large. Soft phosphatic stones of larger size may be crushed, as the surface crumbles away under the nibbling action of the lithotrite.

(*b*) *Hardness* of the stone does not prevent litholapaxy, but hardness combined with size will be a factor in determining removal by lithotomy.

(*c*) An *impacted calculus* is unsuitable for litholapaxy. A calculus impacted in the prostatic urethra which cannot be pushed back into the bladder, a calculus in a diverticulum, a calculus projecting from the lower end of the ureter, or a calculus wedged behind the projecting lobe of an enlarged prostate, should be removed by lithotomy.

2. **Urethra.**—A sufficiently capacious urethra is necessary for litholapaxy.

(*a*) A *narrow meatus* must be incised, and a stricture cut or dilated. If there is a resistant stricture, and especially if the stricture is complicated by fistula, lithotomy is to be preferred to litholapaxy.

3. **Prostate.**—Litholapaxy should not be undertaken when the prostate is enlarged. When, however, enlargement is only present in slight degree, it may sometimes be judged reasonable to advise it. The patient should always be warned that immediate difficulties may cause the operation to be abandoned in favour of lithotomy; also that should retention of urine follow, operation upon the prostate may ultimately be required.

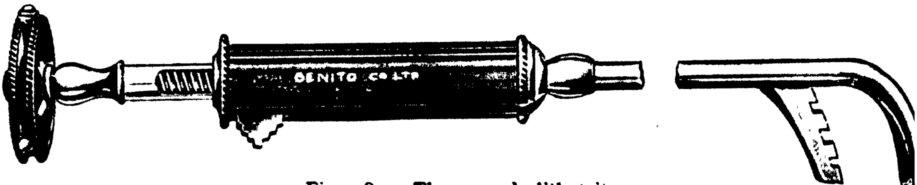


Fig. 982.—Thompson's lithotrite.

4. **Bladder.**—(*a*) *Growth* of the bladder contra-indicates litholapaxy. Cystoscopy is necessary in order to avoid the error of crushing a stone where a growth is also present in the bladder.

(*b*) A bladder with a *diverticulum*, or one with *sacculi*, is unsuitable for litholapaxy. This is for two reasons: firstly the fragments may collect in the sacculus and form a nucleus for further calculi-formation, and secondly, in the process of evacuation the increased pressure in the bladder may rupture the sacculus and produce a pelvic cellulitis.

(*c*) The presence of one or more very prominent *trabeculæ* is a contra-indication to litholapaxy on account of the possibility that such ridges may be gripped by the lithotrite and thereby cause damage to the bladder-wall.

(*d*) A bladder may be so *contracted* as to contra-indicate litholapaxy, but if it holds a few ounces of fluid a stone may be crushed.

5. **Kidneys.**—Where there is a severe degree of infection of the renal pelvis or kidney, or where the renal function is much impaired, lithotomy and drainage of the bladder is a safer operation than litholapaxy.

Instruments.—The instruments necessary for litholapaxy are a lithotrite and evacuating apparatus. Lithotrites of slightly varying construction have been introduced by Bigelow, Guyon, Thompson, Freyer, and others. Two patterns are in common use in the British Isles, namely, Thompson's (Fig. 982) and Freyer's modification of Bigelow's lithotrite. They must be of the best quality of steel and workmanship in order to obviate as far as possible the risk of breaking during crushing.

The simplest form of evacuator is Freyer's single bulb (Fig. 981, B, p. 1993. It is sterilized by being thoroughly filled with 1 : 20 carbolic-acid solution and well covered in this for one hour. Before use, all traces of the solution are carefully washed away in sterile water, and after use it must be thoroughly cleansed of all débris.

Preliminary examination.—The urine is examined to ascertain if infection is present. If there is any doubt about the condition of the kidneys, the renal function should be investigated. The urethra is examined by the passage of large metal sounds (13/15–14/16 English). The bladder should be examined with the cystoscope in all cases before performing litholapaxy. In patients over 50 years of age the prostate should be carefully examined from the rectum, the presence or absence of residual urine ascertained, and the internal meatus should be examined with the cystoscope. Preliminary washing of the bladder, or treatment of the kidneys by diuresis, may be necessary. The bowels should be carefully regulated. A preliminary course of urinary antiseptics should be given, and continued after the operation.

Technique.—The suprapubic region should be shaved and prepared as for a cutting operation.

A low spinal or general anæsthetic may be employed. In a few cases litholapaxy can be carried out under local anæsthesia. The patient lies on a low operating-table, and it is sometimes of advantage to have the buttocks slightly raised. This tilting of the pelvis allows the stone to gravitate to the posterior wall of the bladder, away from the neck. The thighs should be abducted so as to allow for manipulation of the evacuator and for freedom for the movements of the aspirating bulb. The penis is washed with antiseptic, and sterile towels are arranged. The surgeon stands on the right of the patient, and his assistant opposite.

A large (No. 22 Charrière, No. 12 English) silkweb catheter is passed, and the bladder emptied and thoroughly washed with dilute antiseptic solution (oxycyanide of mercury, 1 : 6,000, or boracic) by means of a large bladder-syringe or irrigator. The syringe is preferable, as the tone of the bladder-wall is judged by the injecting hand, and the quantity of fluid introduced can be accurately measured. After irrigation 4 oz. of fluid are injected and the catheter is withdrawn. The lithotrite, which should have been examined beforehand to see that it is in order and that the blades are closed, is well lubricated and introduced.

The passing of a lithotrite is by no means easy in all cases, and, as it is of the utmost importance to avoid injury to the urethra, the manipulation should be gently and carefully done. The shaft of the lithotrite is held horizontally, and about parallel with the right Poupart's ligament, with the beak pointing downwards. The penis is grasped with the left hand and threaded on to the lithotrite, which is raised to the vertical, the handle at the same time being swung medially so that the beak turns into the bulbous urethra and meets the opening of the membranous urethra. The instrument will, with a little gentle manœuvring, slide onwards by its own weight, and the handle is allowed to sink slowly downwards in the middle line. Before it has reached the horizontal the beak will have passed the internal meatus, and by pushing very gently onwards it will advance into the bladder, Throughout these manœuvres the surgeon should be content to guide the instrument and follow it as its weight carries it in, rather than to force its passage.

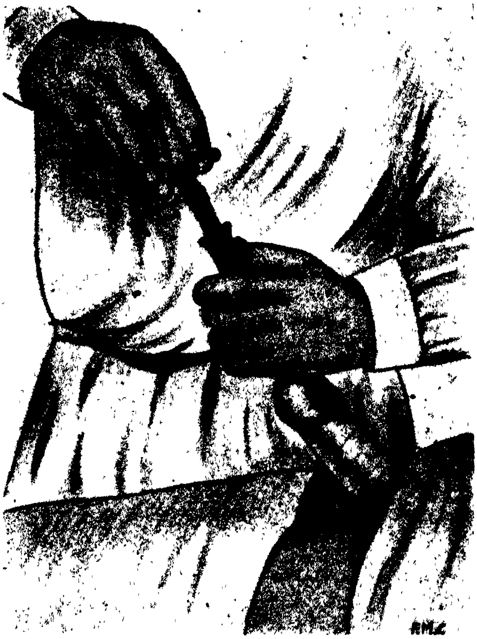


Fig. 983.—Litholapaxy : grasping the stone.

Grasping the stone (Fig. 983) is the next step. The instrument is held at an angle of about 45°, and the beak allowed to rest on the base of the bladder, behind the trigone. The weight of the lithotrite depresses the base of the bladder, and the stone gravitates into this depression. The handle of the female blade is firmly grasped by the left hand, and the blades are unlocked by the right, which then gently draws out the wheel or bulb at the end of the male blade, thus parting the jaws of the beak. A moment's pause is necessary to allow the stone to drop down and come to rest between the jaws, and on closing the latter it should be felt within their grasp. The blades are locked and the stone is firmly held. The lithotrite is now withdrawn for about 1 in., to ensure that the bladder-wall is not gripped, the outer end is slightly depressed to raise the beak away from the bladder-wall, and the wheel of the male blade is firmly screwed home (Fig. 984). The resistance in a hard stone is at first considerable and, when the blades are screwed home as far as possible, it may be necessary to wait a few seconds before the stone suddenly cracks, with a sound easily heard by the operator. Occasionally it may be necessary to release the stone and grasp it again in a fresh axis before the first splintering is accomplished. The blades are now unlocked, and the process is repeated until all the fragments are crushed.

During the whole of the crushing, the lithotrite is kept in the middle line of the body. The left hand grasps the handle firmly and rigidly, and is only removed when a change of position of the beak is required.

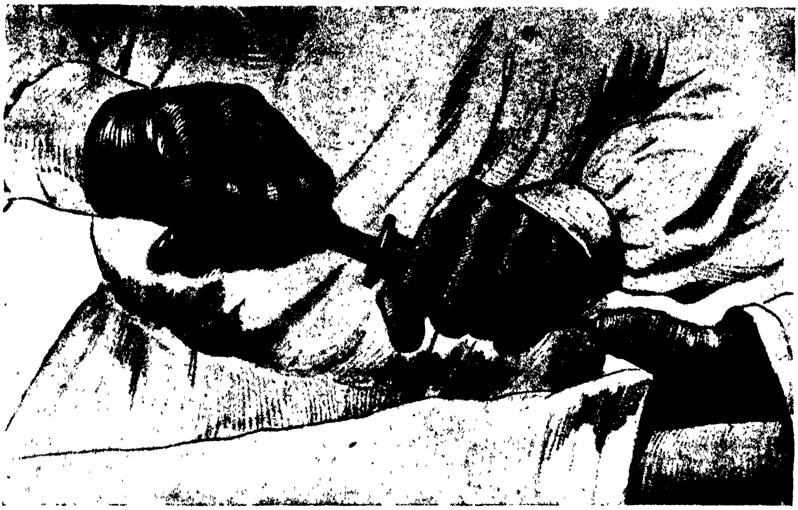


Fig. 984.—Litholapaxy : crushing the stone.

The right hand controls the wheel or bulb which it locks when a fragment is engaged and frees when this has been crushed. When no further fragment can be engaged in the blades, the lithotrite is removed and a cannula, the largest that will pass without damage to the urethra, is introduced ; the fluid contents of the bladder rush out. The stone fragments have settled at the floor of the bladder, and remain there. The bladder is washed with several syringefuls of lotion, and 4 oz. of fluid are introduced. The evacuating bulb, filled with dilute antiseptic solution, is attached to the cannula and the stopcock is turned. There must be no air in the system as it impairs the force of inflow and suction. The bulb is held so that the cannula is at an angle of 45° and the beak of the cannula lies at the base of the bladder in the same position as that occupied by the beak of the lithotrite (Fig. 985). The left hand now supports the cannula, and with it bears the weight of the bulb. The right hand grasps the rubber bulb and compresses it with a firm grasp. The fluid is forced out of the bulb into the bladder, and the powerful current sweeps the fragments off its floor. When the grasp on the bulb is released, the fluid rushes back from the bladder and, before the fragments have had time to settle, sucks them into the bulb, and thence they fall into the glass container beneath it. The alternate systole and diastole of the evacuator is repeated until no more fragments appear.

After compression the bulb may refuse to expand. This is due either to a fragment impacted in the eye of the cannula, or to the mucous membrane being sucked in by the diastole. A further squeeze of the bulb will free the mucous membrane, and the cannula is placed so as not to repeat this error of technique. If the fragment of stone is too large to pass, the aspirating bulb is detached from the cannula and a stylet passed along the lumen and sharply pushed home. A rush of fluid shows that the fragment has been displaced into the bladder. Fluid (4 oz.) is again introduced into the bladder, the lithotrite re-introduced, and the fragment crushed and evacuated.

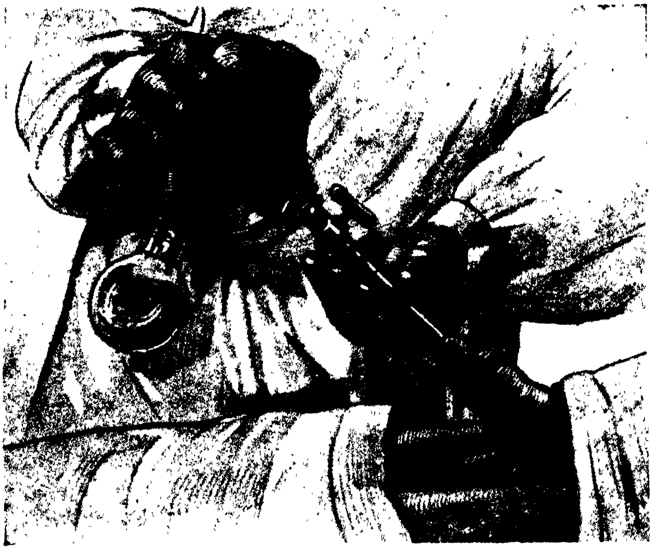


Fig. 985.—Litholapaxy : removal of fragments by evacuating bulb and cannula.

But when all the fine débris has been removed, there may still be a clicking noise at each diastole of the bulb, due to the impact of one or more fragments too large to pass the cannula. In this event the process of crushing and evacuation must be repeated. The most difficult fragment to pick up with the lithotrite is a flat scale from the outer surface of a large stone.

The operation is finished when the lithotrite no longer feels a fragment, but a more reliable test is the evacuator, for small fragments and débris cease to fall into the glass container. Search is now made with the cannula in different parts of the bladder, compression of the bulb being made in each position, but the cannula being quickly turned to its usual position, eye upwards, before suction is allowed. This manœuvre prevents the mucosa being sucked into the eye of the cannula.

If any fragment is left, it will either be swept into the evacuator or will be felt and heard to click against the cannula, and will necessitate re-introduction of the lithotrite. For small fragments at the end of a litholapaxy a smaller lithotrite may be used.

The bladder is now thoroughly washed out through the cannula. When the fluid runs clear the bladder is distended with 6 or 8 oz., the cystoscope introduced, and the whole of the interior of the bladder inspected, the use of a flushing cystoscope greatly facilitating this examination.

If the operation has been carried out successfully there should be little more than a trace of blood in the wash. In such a case, and where the bladder has been clean before the operation and there is no enlargement of the prostate, the patient may be returned to bed without a catheter in the urethra. Where, however, the stone has been a large one and there has been a good deal of bleeding from an inflamed mucous membrane, or where the bladder is septic or the prostate has shown some enlargement, a catheter should be tied in the urethra for forty-eight hours or longer, and during that time the bladder frequently washed with weak antiseptic solution. In most instances litholapaxy, including a preliminary and subsequent cystoscopy, may be easily completed in less than half an hour.

When a stone of moderate size has been crushed in a clean bladder, the patient may get up on the third day, and leave for home at the end of a week or even sooner. But if the stone was large and urinary sepsis present, a longer stay will be necessary.

Complications.—The risk of rupturing a sacculus by the forcible use of a Bigelow's evacuator has already been alluded to as one of the contra-indications to the operation (*see* p. 1994) and mention has also been made of the risk of accidentally crushing a prominent trabeculum, if one is present. This might lead to such serious laceration of the bladder-wall that perforation would result. If the lithotrite was used in an almost empty bladder, similar damage might be inflicted. Apart from this, if litholapaxy is carried out according to the technique described, the bladder-wall will not be damaged. The only likely complication besides hæmorrhage, which should never be severe if the cases are properly selected, is fever. A rise of temperature following a rigor may occur after litholapaxy in a bladder already infected. A catheter retained in the urethra for a few days will usually prevent this, and the bladder should be carefully and assiduously washed. The surgeon should be on the look out for pyelitis, indicated by a rise of temperature and pain in the kidney region, and for epididymitis. In a few instances retention of urine may follow litholapaxy, and is then likely to be due to a minor degree of prostatic obstruction which has been increased by temporary swelling following the instrumentation. It should be treated by an in-dwelling catheter for a few days, when the condition usually subsides. Occasionally, however, some form of operation upon the prostate becomes necessary.

Very rarely, in spite of careful preliminary investigations, a stone unsuitable for litholapaxy may be met with, for example one containing a foreign body as its nucleus. For this reason the instruments necessary for cystotomy should always be available, and the patient warned of its possibility.

LITHOLAPAXY UNDER VISION

Lithotrites which are combined with a cystoscopic system (Fig. 986) can be employed to crush stones in the bladder, but the grasp of these instruments is not more than half an inch, and for this reason the method can only be used for small stones. Although a soft phosphatic calculus of this diameter can be grasped and crushed, this is not possible with hard stones—for example, one composed of calcium oxalate—for sufficient force cannot be employed to break it. Stones of dense composition may sometimes be broken up by a process of nibbling. Therefore, the method, though useful, is one of strictly limited application, and such instruments are necessarily much larger than an ordinary lithotrite with a grasp of the same dimensions.

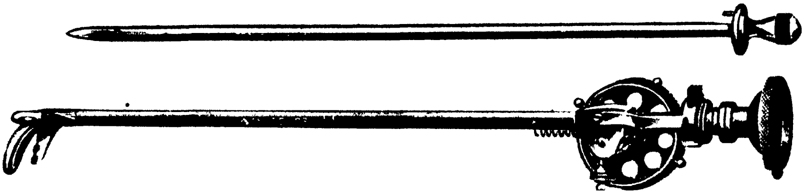


Fig. 986.—Canny Ryall's cystoscopic lithotrite.

LITHOTOMY

The cutting operation for stone may be done by the perineal or by the suprapubic route, the latter being the operation most generally employed.

Median perineal lithotomy.—Median lithotomy is performed for vesical calculus where there is a stricture of the urethra which it is necessary to treat by an external cutting operation. The procedure is similar to external urethrotomy (*see* p. 2116). As soon as the gorget is passed, the finger enters with it and locates the stone, the gorget being withdrawn. The stone is then seized in suitable forceps and removed.

Suprapubic lithotomy.—This operation is performed for all cases of stone where litholapaxy is contra-indicated and when there is no special indication for perineal lithotomy. The procedure is the same as for the operation of cystotomy (*see* p. 1980). The size of the incision in the bladder will vary with that of the calculus; in many cases a small opening is sufficient. Through it, lithotomy forceps (Fig. 987) are introduced and with these the stone is picked up and removed. If, however, this is not easily effected, it is best to enlarge the incision and introduce bladder retractors; the stone can then be picked up under vision. This procedure should always be employed if there are several stones, or if, being composed of phosphates, they are unusually friable, since it is of great importance that no stone or fragment should be left in the bladder itself or in the tissues outside it. The bladder may be flushed with lotion from an irrigator, a suction apparatus being used to remove the fluid. In every case the bladder should be thoroughly examined, illuminated retractors being introduced and the patient put in the Trendelenburg position if necessary. It may be difficult to extract very large calculi from the bladder, particularly if a portion extends into the prostatic urethra. An assistant, by exerting upward pressure upon the perineum, or with two fingers introduced into the rectum, may assist in dislodging them.

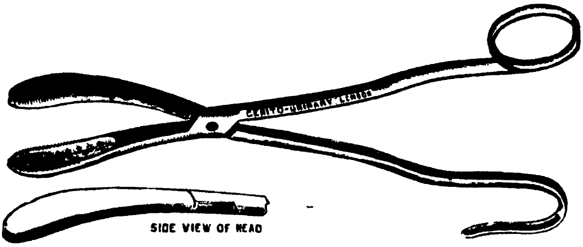


Fig. 987.—Lithotomy forceps.

The operation may now develop into the removal of the prostate, of a growth, or of a diverticulum ; or only drainage of the bladder may be required. In the latter case a tube such as is used in cystostomy is placed in the bladder, and the wound closed around it. A small prevesical drain is introduced and the abdominal wall sutured.

Vesical Calculus in Children

Litholapaxy.—There are objections to litholapaxy in children, in whom the urethra is very small and narrow, and its mucous membrane delicate and easily torn. Further, the bladder is small and pear-shaped, so that the space for manipulation is confined. Special instruments of small size are necessary, and the surgeon should be provided with a series ranging from No. 4½ to No. 10 English scale. Boys from 13 to 16 years take a lithotrite of No. 11 or No. 12 size. No stone with a diameter of more than ½ in. can be crushed in an infant of either sex, or with a diameter of 1 in. in a boy. The cannulæ suitable for children vary from 6 to 11 English scale. The small-sized cannulæ should be short, as the suction power is diminished by the small lumen. The aspirator is used with the utmost gentleness, and only a small quantity of fluid is passed into the bladder at each systole.

The calibre of the urethra at different parts varies more in the child than in the adult. The meatus and first inch and a half are the narrowest part of the urethra in the child. Having passed this, the lithotrite enters the bladder without further difficulty, except for a slight hitch at the internal meatus. The operation in children takes longer, and there is more danger of leaving fragments behind, but this can be avoided by care and experience. If the lithotrite does not lie easily in the canal there may be difficulty in withdrawing and reintroducing the instrument. For this reason special care should be taken to finish the crushing before withdrawing the lithotrite, and this must be very thorough, as the cannulæ used only permit the passage of small fragments. Cystin calculi may be very hard and not at all friable, or the fragments may cling to and clog the jaws of the lithotrite. Therefore, when a small instrument has to be used, as in children, litholapaxy is contra-indicated and lithotomy should be substituted.

Lithotomy.—In infants and small children, particularly males, lithotomy is the operation of choice, for the bladder is readily accessible and the stone very easily removed. Unless sepsis is severe the bladder can be closed completely, the first suture being a continuous one through all the coats, the second of Lembert type, to invaginate the first. The abdominal wall is closed and a corrugated rubber drain is placed in the lower part of the incision in case there should be any leakage. An in-dwelling catheter is not essential, though most surgeons prefer to have one.

Results of operations for stone.—The following table (St. Peter's Hospital Reports) shows the results of operation in 2,532 cases of uncomplicated stone in the bladder performed at St. Peter's Hospital since 1864. The sudden drop in the operative mortality owing to the introduction of litholapaxy is seen in the third decade.

Decade	*Operations*	*Cured*	*Deaths*	*Percentage of Deaths*
1864–73	118	100	18	15.25
1874–83	196	166	30	15.30
1884–93	362	332	30	8.29
1894–1903	600	571	29	4.80
1904–13	578	559	19	3.28
1914–23	397	379	18	4.53
1924–33	289	281	8	2.76

During the period 1924–36 516 operations were performed for vesical calculus with the following results :

	Operations	*Cured*	*Deaths*	*Percentage of Deaths*
Litholapaxy	252	247	5	1.98
Simple lithotomy	120	114	6	5.00
Lithotomy with another operation	144	126	18	12 50

The following were the combined operations :—

	Operations	*Deaths*
Lithotomy and prostatectomy	130	15
Lithotomy, prostatectomy and diverticulectomy	4	1
Lithotomy and diverticulectomy	4	1
Lithotomy and for vesical-neck obstruction	3	1
Lithotomy and excision of growth	2	0
Lithotomy and uretero-lithotomy	1	0

Sir Henry Thompson published 1,005 operations for vesical calculus, with the following results :

Perineal lithotomy . . .	. 136 with 44 deaths .	32.35 %
Supra-pubic lithotomy .	. 19 with 5 deaths .	26.31 %
Lithotrity	. 850 with 49 deaths .	5.76 %

The high mortality in lithotomy was due to the fact that the worst cases were treated by cutting operation, and lithotrity was employed in the less serious cases. Of the 850 cases of crushing operation, 472 were done by the old method of lithotrity by repeated sittings, with 37 deaths (7.83 per cent.), whereas 372 were done by lithotrity at one sitting (Bigelow's operation of litholapaxy), with 12 deaths (3.22 per cent.).

OPERATIONS FOR FOREIGN BODIES IN THE BLADDER

A foreign body in the bladder is usually recognized by cystoscopy and radiography. In some cases, however, these investigations will only show a calculus and the foreign body which forms its nucleus will be unsuspected. The dangers of litholapaxy in such instances have been alluded to on page 2000.

1. **Cystoscopic extraction.**—It may be possible to remove a small foreign body through a suitable cystoscope.

2. **Solvents** may be used for foreign bodies composed of candle-wax, bees-wax, chewing gum and similar substances (provided that the exact nature is known). Capels's experiments are worthy of note. He used a series of test-tubes containing cubes of wax from the same candle as that of which the foreign body was composed. Xylene, kerosene, and gasolin were incubated in respective test-tubes at 37° C., a little urine being added every few minutes. The cubes dissolved in gasolin and xylene in ten hours, in kerosene in eleven hours, and in a solution of 33 per cent. gasolin and paraffin oil in twelve hours. He then injected 125 c.c. of the last solution at 110° F. into the bladder. This was retained for 1½ hours. Six subsequent injections were given during the next few days, the wax being precipitated by chilling the return flow. The sixth and seventh specimens were found to be wax free, and on cystoscopy the bladder was clear.

3. **Suprapubic cystotomy.**—In the majority of cases this is the only method suitable. Foreign bodies are often enveloped in a coating of friable phosphatic deposit. The opening in the bladder should be adequate to remove the object intact and to ensure that no pieces escape notice. Suprapubic bladder drainage is necessary.*

OPERATIONS FOR TUMOURS OF THE BLADDER

Before undertaking the treatment of a bladder-growth either by cystoscopic methods or by open operation, a careful examination must be made, so that an opinion may be formed on the character of the growth and its extent and accessibility. It should be remembered that almost all growths of this viscus are potentially malignant. At the preliminary cystoscopy the following points should be noticed :

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* Badenoch and Campbell, "Foreign Bodies in the Urinary Bladder with a report of two cases," *Brit. Journ. Surg.*, 1937, xxv, No. 97, 133.

1. The number of growths.
2. The position of the growths and relation to the internal meatus and ureteric orifices.
3. Whether the growth is pedunculated or sessile.
4. The character of the surface, whether fimbriated, raspberry-like, smooth, nodular or irregular. Whether it bleeds easily.
5. Evidence of infiltration, ulceration, phosphatic deposit, or necrosis.
6. The presence of cystitis.

Small portions of a growth can be removed by cutting forceps or a snare, through an operating cystoscope, but the information obtained from their histology is usually not helpful. One reason for this is that the base is not included. But even when a papilloma has been completely resected by open operation the microscopical examination of it fails to give certain indication of recurrences which may develop. Millin * has described a method for the easier removal of larger pieces through a special resectoscope and expects better results.

The diagnosis of malignancy on cystoscopic evidence is founded on one or more of the following characteristics :

The growth is smooth and nodular or, if villous, the villi are thick, stunted, and closely packed and do not wave about in the medium. Blood-vessels, instead of forming loops in separate villi, course over the surface. There is necrosis of the growth, phosphatic deposit on its surface, and cystitis which is not the result of surgical interference. There is œdema of the mucous membrane at the margin of the growth. At some part of the circumference there is evidence of dragging on the mucous membrane, as shown by radiating puckers. Small nodules may be present in the mucous membrane, near the main growth. The diagnosis between simple and malignant growth is usually made without difficulty by an experienced cystoscopist. Much valuable information is obtained from a bimanual examination. A villous papilloma is not usually felt in this manner unless it is very large, and then only as a soft mass. An infiltrating growth, on the other hand, is almost always palpable. The involvement of the bladder-wall and the extension outside it which is thus ascertained is often much greater than the cystoscopic appearance suggests. In the female, even very small nodular growths on the posterior wall can be felt on vaginal and bimanual examination.

There are several forms of treatment, and these depend largely on the extent, nature and position of the growth.

Growths invading the bladder from without.—In a few cases growths of the bowel may become adherent to the bladder, and if resection of the intestine is practicable, this should be combined with partial cystectomy, removing the affected part of the bladder widely. The operation is necessarily intraperitoneal. At the conclusion of the partial cystectomy the bladder should, if possible, be closed entirely with two layers of sutures, after a large-sized catheter has been placed in position in the urethra. If this cannot be safely undertaken, cystostomy must be performed.

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* "Tumours of the Urinary Bladder with Description of a New Endoscopic Technique," *Brit. Journ. Surg*, July, 1937, xxv, No. 97, 145.

GROWTHS OF THE BLADDER JUDGED TO BE NON-MALIGNANT

1. TRANSURETHRAL OPERATION BY DIATHERMY COAGULATION

Diathermy coagulation through a cystoscope is the method of choice in the treatment of all *benign* papillomata whenever it is practicable. Even when large areas of the bladder-wall are involved it often proves successful. Many sessions may be necessary, and the treatment may spread over a period of months at intervals of 4 weeks, but if the surgeon perseveres and the patient is tolerant, excellent results can be obtained. Papillomata of doubtful malignancy can also be treated by this method for purposes of diagnosis. If the response is good the probability is that the growth is benign, but should the effect of diathermy be unfavourable and the growth be observed to be regenerating rapidly it is probably malignant; no harm is done thereby, for provided the patient is kept under close observation more radical treatment can be carried out whenever the need becomes apparent.

Apparatus.—A high powered diathermy machine is required. In this country these are designed to work on alternating current varying from 100 to 240 volts. If only direct current is available, a rotary converter is required to change the current to alternating. Three flexes are attached to the diathermy machine. One leads to a foot-switch. A second goes to a lead pad (say 6 by 8 ins.) which is wrapped in numerous layers of lint soaked in a strong brine solution. This is the indifferent electrode and is placed on the patient's abdomen, or beneath the buttocks, the latter being the ideal site if the lithotomy position is selected. If the patient's weight is resting on the pad, a piece of dry cotton-wool should be placed between the skin and the point of attachment of the flex to the pad. The largest possible area of this indifferent electrode should be in close contact with the skin. This is particularly important when a considerable strength of current is being employed. The pad should not be placed on the chest, as in thin patients it may only make contact with the skin over the ribs, nor upon the thigh, as in this case only the uppermost edge will be active. The third flex, which should be sterilized by boiling, is for attachment to the active electrode which is to pass through the cystoscope. The active end of this electrode may be blunt, pointed, or in the form of a ball; the last-mentioned can only be introduced through the more modern types of cystoscope. At least two electrodes should be available.

The *cystoscope* should be an operating one for choice, otherwise of the single catheterizing type, and it should be fitted with two taps, so that the bladder cavity can be flushed throughout treatment. A tube from a reservoir on a stand leads to one tap, and from the other an out-flow tube drains into a bucket on the floor. The reservoir should be filled with sterile water, not antiseptic solution, at a temperature of 90°–110° F. The top of the fluid should not be more than 2 ft. above the level of the bladder.

The diathermy machine is set for the coagulating current, and the strength of this is adjusted to a suitable amount, which will be proportionate to the size of the point of the electrode. It is wise always to start with a low intensity and increase it, if necessary, after trial upon the growth. If the operator is unfamiliar with a particular diathermy machine, a good idea of the intensity of the process can be obtained by testing the apparatus beforehand upon a piece of raw meat placed in a bowl of water.

Technique.—In some cases treatment can be undertaken without an anæsthetic, or with only desensitization of the urethra by local anæsthesia. Papillomata are insensitive to the current, except those of the very sessile velvety type, though pain will always be felt if a high-intensity current is used, or if the surrounding mucosa is cauterized. This method is, therefore, chiefly used for small growths and recurrences, more especially in the female. As a rule, it is better that the patient should be anæsthetized, a low spinal anæsthetic being very suitable. Much more intensive treatment can then be undertaken and a growth of considerable size can often be entirely destroyed at one session.

Before starting treatment a record should be made of the position and size of the growth or growths in order to check the results obtained. This can conveniently take the form of a diagrammatic chart of the bladder interior. When the amount of growth to be destroyed is small, the bladder should be distended with about 8–10 oz. of fluid, and there will be no need either to flush or irrigate the bladder. If, however, the treatment is likely to be prolonged, it is better to begin by injecting not more than 6 oz., as this will allow further gradual distention by flushing, which will greatly help to keep the field clear. Care must be taken not to over-distend the bladder, but 15 oz. or even more is ordinarily tolerated.

When the cystoscope has been passed, a general quick review of the bladder should first be made to compare with the appearances observed at the previous cystoscopy. The electrode is then introduced until its point is touching the growth, or is even pushed into its substance for a few millimetres. The diathermy current having been switched on, the current in the active terminal is controlled by the foot-piece and coagulation of the growth is commenced. If continuous irrigation is being used, when it is judged that the bladder is becoming full, the inflow tap is closed and the outflow tap opened. While the fluid is running out it is usually necessary to stop the coagulation. As soon as the bladder is empty, the tap is closed and the inflow again opened. It is during refilling that coagulation is most easy, as the bubbles which form are carried out of the field of view. Thus the process of filling and emptying alternates throughout the treatment. When dealing with a large growth and using a big electrode the telescope, and if possible the electrode and its guide, should be removed from the sheath, and at intervals the bladder washed out with a syringe, thus removing large pieces of detached growth, and again obtaining a medium clear of blood and débris. The whole surface of the growth should be systematically coagulated ; this stage is reached when the villi lose their pink colour and only a greyish-white surface is seen. If a satisfactory view can be obtained of any growth in a remote or difficult position, such as in the lateral horns of the bladder, at the internal meatus, or near the vault, this should be dealt with first while the medium is clear and the view is good, the larger and more easily accessible growths being treated afterwards. With this reservation, that portion of a growth which is nearest the operator is first coagulated, for destruction of this will give a better view of parts which have previously been obscured. In exceptional cases it is possible to apply the electrode direct to the pedicle of the growth, and to coagulate this completely, or even to divide it. This particular method, however, should always be adopted with caution as, unless a clear view is obtainable, the bladder-wall beyond may be seriously burned.

It is important to keep the end of the electrode clean, and if much tissue has to be treated, it should be frequently changed, a spare one being used while the other is thoroughly cleansed and polished. If growths are multiple, and it is obvious that more than one treatment will be required, it is better that each should to some extent be coagulated rather than that a prolonged attempt should be made to destroy one of them entirely at a single session. When the latter is possible, however, the growth should be burned right down to its base, and a small margin of the surrounding mucosa coagulated. At the end of the treatment the bladder is again washed out. If the coagulation has been extensive the patient should be kept in bed for the next twenty-four hours. When one of the larger types of electrode has been used there is a definite risk of secondary hæmorrhage as sloughs separate. Such bleeding is uncommon if an electrode with a small active end is used.

Growths of considerable size, yet not so big that an open operation is required, can be dealt with by Kidd's diathermy cystoscope (Fig. 988). The electrode of this instrument is larger than can be used in any other cystoscopic method, and the amount of destruction produced is very great. For this reason it must be used with particular caution. If the growth treated is near a ureteric orifice the resulting œdema may be sufficient to block it entirely for some days (an effect which can also be produced with much smaller electrodes by very vigorous treatment of a growth at such a site). The sloughs which form when this electrode is used are large and the patient may have difficulty in voiding them. It may be necessary to pass the cannula of Bigelow's evacuator, and to remove them by suction ; this should be done very gently. Secondary hæmorrhage is not uncommon and may be severe.

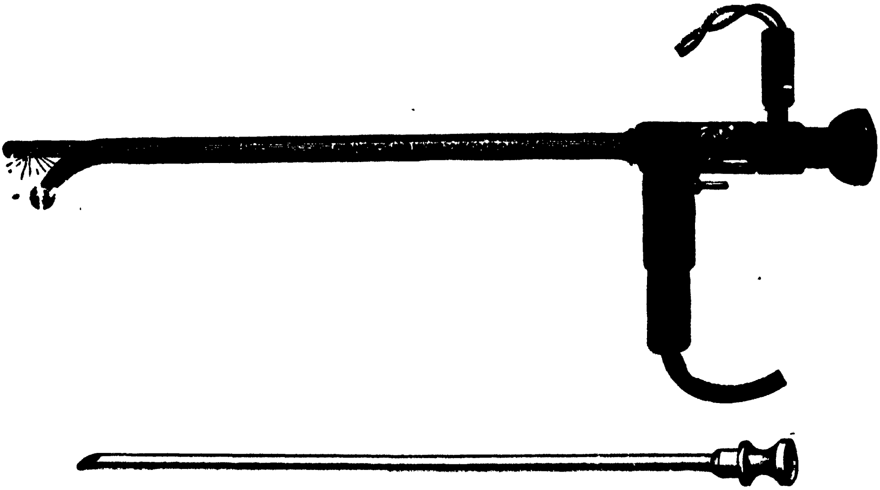

Fig. 988.—Kidd's diathermy cystoscope.

Difficulties.—1. **The position of the growth.**—If the growth is situated at the internal meatus, treatment is not easy through the usual type of cystoscope, but can be undertaken without difficulty, if a suitable cysto-urethroscope is employed ; through this, growths extending from the external urinary meatus into the urethra can be destroyed efficiently. A growth at the apex of the bladder may be difficult to approach, but pressure on the abdomen will usually bring it into an accessible position, and will also displace the air-bubble, if this tends to obscure the view. The bubble can also be got out of the way by giving the patient a slight lateral tilt. There is an area immediately anterior to the internal meatus and extending up behind the symphysis pubis which, in the male, is often invisible with the ordinary cystoscope. In the female this is absent, or the area is small. In men, therefore, a growth in this region may be missed even after it has attained considerable size ; fortunately such growths are uncommon. Under anæsthesia, if the ocular end of the cystoscope is fully depressed, the extent of this area is diminished, but only with a retrograde-view telescope is full examination possible. Transurethral treatment of growths arising here is sometimes impracticable.

2. **Hæmorrhage.**—This may be either reactionary or secondary. In most cases it is not severe, and all that is necessary is to put the patient to bed and establish profuse diuresis. If, however, the bleeding is severe, the patient should be anæsthetized, a flushing cystoscope introduced, and the bleeding-point sought and cauterized.

This should be done before large clots accumulate. If clot-retention has occurred it is sometimes possible to empty the bladder by gently using a Bigelow's cannula and evacuator, and then to treat the bleeding-point through a cystoscope. In such cases, however, it will often be necessary to open the bladder. The removal of clots and the provision of bladder drainage is usually all that is necessary, but if a bleeding-point is seen it should be coagulated with diathermy.

Contra-indications.—1. If the growth appears to fill the cavity of the bladder completely, or if its extent is very great, the method is rarely practicable.

2. **Cystitis.**—This in severe degree renders the case unsuitable for transurethral diathermy.

3. **The prostate.**—Enlargement of the prostate, if considerable, may interfere with the necessary movements of the cystoscope. Further, the instrumentation may precipitate acute retention of urine.

After-care.—When transurethral diathermy-coagulation is used in the treatment of bladder papillomata it is most essential that the case should be carefully followed up. If the growth has been apparently destroyed, cystoscopy should be repeated in about one month. If the bladder is then clear, an examination should be made at three-monthly intervals for twelve months, at six-monthly intervals for twelve months, and then once a year until at least five years has elapsed without recurrence.

2. OPEN DIATHERMY-COAGULATION

This treatment is used for both benign and malignant growths. Benign growths of small or medium size are usually dealt with by cystoscopic diathermy (p. 2005). If too large for this treatment, excision may be employed (p. 2011). Open diathermy-coagulation is reserved for cases in which the growths are too numerous to be dealt with by the first method; too sessile and widespread to be dealt with by the second; or too large for either. It is particularly useful when a large growth is so close to the internal meatus that resection is impossible. The indifferent electrode, covered with lint soaked in brine, is placed beneath the patient's buttocks, the bladder is exposed as for cystotomy, and opened, with the special precautions mentioned on p. 2011, by an incision which, in the light of information gained by previous cystoscopy, is, if possible, planned to avoid any growth. A self-retaining bladder retractor is inserted, and the current is set to diathermy of medium strength. One of the ball electrodes, as used for open diathermy, is attached to the sterile flex leading from the machine, and is applied to each growth in turn, the current being then switched on. The process must be carried out with caution and always with a clear view, as a large amount of destruction results, and care must be taken to avoid damage to the bladder-wall, from which a perforation might result. The necrotic pieces are removed, and the bladder from time to time is swabbed out, cold lotion being used, as great heat is generated by the diathermy current. Each growth and the mucosa around it for a distance of a few millimetres is thus destroyed. An alternative method is to cut away the more superficial parts of the growth by means of a diathermy loop until nearly level with the bladder wall, the destruction then being continued with a ball electrode. When a growth situated round a ureteric orifice is treated in this manner, temporary blockage of the duct is very likely. If, therefore, the opposite ureter is also involved, treatment of one side must be postponed.

MacAlpine has designed a special "indifferent" electrode in the form of a metal spoon on a bakelite handle (Fig. 989). This is attached to a sterile diathermy lead in place of the one ordinarily connected to the pad beneath the patient's buttocks. It is suitable for dealing with large papillomata, particularly pedunculated ones. After the bladder has been opened, the spoon is placed beneath the growth, and the surface nearest to the operator is then treated with the ball electrode, the current passing from this through the tumour to the spoon. When the surface of the growth has been coagulated and the risk of re-implantation in the incision thus diminished, a freer manipulation is possible, and the relationship to the ureteric orifice can be ascertained, together with the presence or otherwise of a pedicle. If a pedicle is present it can be divided with a diathermy needle. For a sessile growth, coagulation is continued until the base is approached, the spoon-electrode is then removed and the lead connected to the pad electrode.

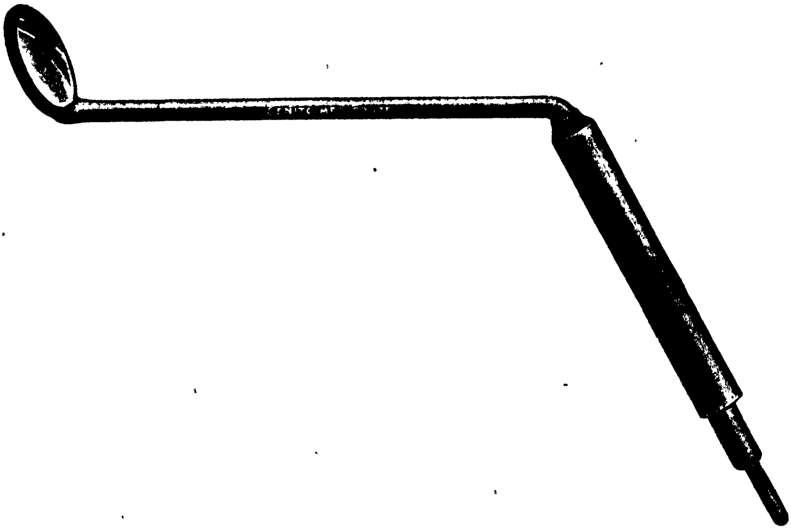

Fig. 989.—MacAlpine's indifferent electrode.

A papilloma which is obviously *malignant* may be dealt with, as a palliative measure, as just described, although resection is the method of choice. If it is employed, a larger area of surrounding mucosa should be coagulated than when dealing with a benign growth. In a few cases open diathermy may become urgently necessary for the arrest of hæmorrhage. Infiltrating growths should not be treated by diathermy. Not only will no benefit accrue, but very severe sepsis will result.

Healing after open diathermy-coagulation of a bladder growth is not so rapid as after excision. Drainage is always necessary and the tube should not be removed until at least three weeks after the operation. During this time the bladder is irrigated twice or more daily.

3. EXCISION OF NON-MALIGNANT TUMOURS

If the case is considered unsuitable for transurethral diathermy-coagulation, it may be treated by diathermy applied after the bladder has been opened (p. 2019) or it may be excised. The excision of benign papillomata has been largely replaced by diathermy methods, but it remains a method of treatment if no electrical apparatus is available, and it is sometimes chosen for very large growths. The operation will therefore be described as carried out under these conditions, though I shall also indicate how the diathermy current may usefully be employed even when excision rather than coagulation is selected.

The chief risk attending excision of a benign papilloma is that cells may become implanted in the open tissues of the wound where this traverses the abdominal and bladder walls. Should implantation occur, the growth which develops is an infiltrating carcinoma, even though the original bladder neoplasm was characteristically benign. Various means are adopted by different operators to minimize this risk, but by far the most important is to avoid rough handling of the growth, since this detaches cells from it. Recurrence in the wound is very likely when a papilloma is exposed and excised through a small incision, for in these conditions removal cannot be performed with delicacy and the damaged surface of the growth will inevitably brush against the raw tissues of the incision during its removal. Swabbing of the bladder cavity should be restricted as much as possible.

Technique.—The preliminaries are as described on page 1981. Some surgeons use solutions of silver nitrate varying in strength from 1 : 10,000 to 1 : 500 to distend the bladder, or the viscus may be washed out and left empty. It is essential when opening the bladder to avoid cutting into the growth. For this reason its position must have been carefully determined by preliminary cystoscopy. The growth is somewhat more likely to be accidentally damaged if an empty bladder is opened; on the other hand, when a distended bladder is opened there is a risk that the escaping fluid may carry neoplastic cells with it, if any have become detached.

The patient is placed in the Trendelenburg position. The incision in the abdominal wall should not be less than 4 in. in length. The bladder may be opened with a diathermy needle and the lotion within withdrawn by suction. The site of the growth is now more precisely ascertained by inspection before the incision is extended in the required direction and to the length necessary to give full and free exposure. Tetra cloths are used to surround the margins of the wound, including those into the bladder. They may be soaked in silver nitrate solution 1 : 1,000, and self-retaining retractors are introduced (Fig. 990). By their aid and by stay sutures the bladder is lifted well up towards the surface and so maintained throughout the operation. From this stage onwards the instruments used for touching the growth should be kept separate, and either put aside or resterilized when the excision is completed. Diathermy is again of great value at this stage, even if excision and not coagulation is intended and, if it is available, before proceeding further the whole surface of the growth should be electro-coagulated, thus greatly minimizing the risk of implantation in the

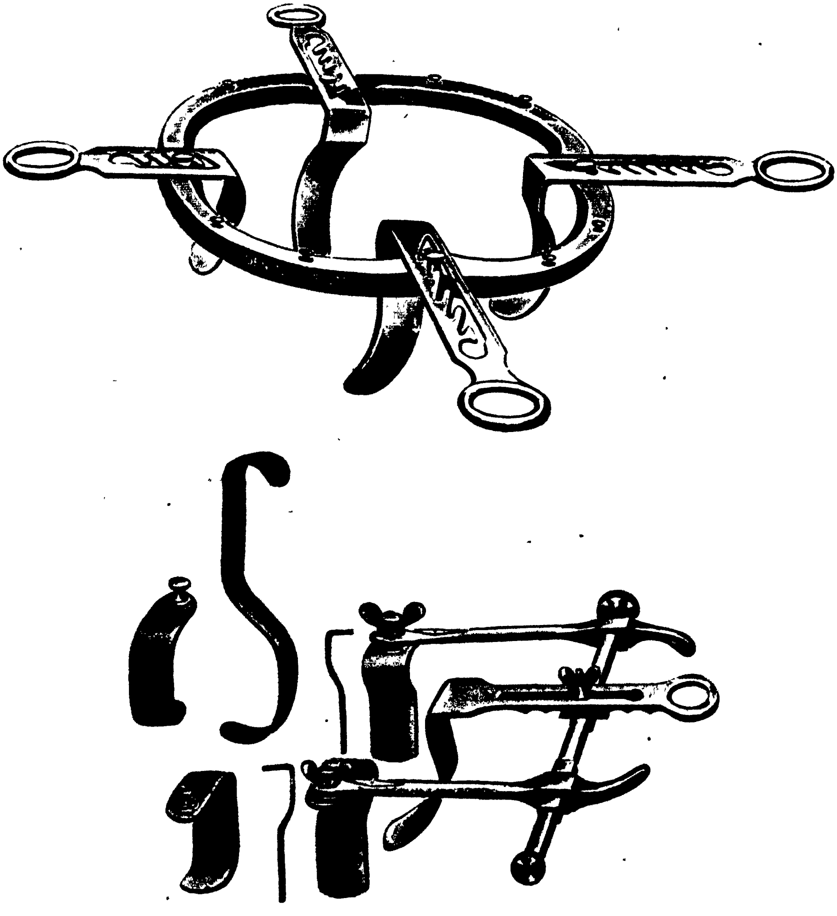

Fig. 990.—Self-retaining bladder retractors. (A) Joly's; (B) Thomson-Walker's with anterior blade.

wound. With the same object, silver-nitrate solution, 1 : 500, or absolute alcohol may be applied to the surface of the growth.

The relationship of the growth to the ureteric orifices and to the internal meatus is examined. If it is pedunculated, the stalk is picked up with dissecting-forceps and raised sufficiently to lift slightly the mucosa from which it takes origin. Here it is divided, preferably with a diathermy needle, otherwise with long curved scissors or a knife, and the growth is removed with a minimum of damage. Spurting vessels are picked up with pressure forceps and tied, and the incision is closed with continuous or interrupted sutures of No. 1 plain catgut. Sessile growths are excised by cutting through the healthy muscosa around them with a knife or long scissors. If there is more than one growth, each is dealt with in a similar manner. Care must be taken not to obliterate the ureteral orifice. Growths at the internal meatus are the most difficult to deal with by this method since to be effective the whole of the mucous membrane from which the growth takes origin must be removed.

Great masses of soft papillomata which fill the bladder can only be satisfactorily dealt with by diathermy current. If, however, this is not available the papillomata should be held in Duval's grab forceps and rapidly cut away in spite of bleeding ; the bladder is then packed with gauze, the packing allowed to remain for a few minutes and then quickly removed. Any considerable bleeding-points will be seen and secured by pressure forceps and a stitch. Small papillomata which still remain will be seen and removed. The bladder is now thoroughly swabbed with nitrate of silver solution and a large tube is inserted.

When hæmostasis has been good, and particularly when a pedunculated papilloma has been excised from a non-infected bladder, the wound may be closed completely. In most cases it is desirable to drain the bladder and close the wound as described on p. 1985. The after-care is similar to that of other cases of cystotomy.

Malignant Tumours

1. partial cystectomy

The extent and method of the operation will vary according to the position and size of the growth, information in regard to which will have been obtained by means of cystoscopy and bimanual examination. The guiding principle should be to remove from the bladder itself what may be considered to be an intensely irritating foreign body wherever this is possible, death from metastases (which are most commonly found in the pelvic bones and pelvic tissues) being preferable to the suffering which results from progressive vesical carcinomatosis. The operation should not be abandoned because enlarged glands are discovered, provided the growth can be removed, but no attempt should be made to include glands in a block dissection ; even if it is obvious that no cure can be obtained, a patient will undoubtedly be spared much suffering by the removal of the vesical tumour, as quite often there is no local recurrence.

The bladder is first washed out. It is usually left empty, although it is doubtful if the risk of implantation is increased by leaving it distended. The table is placed in the Trendelenburg position, and a midline incision is made, extending upwards from the level of the symphysis pubis for some five inches. The rectal sheath is divided in the same line, the recti retracted and the peritoneum and bladder exposed. The skin, subcutaneous and muscle layers are carefully packed with skin-towels, and the operation is continued according to the position and size of the growth.

1. **Growths situated at the upper part of the bladder.**—If the growth has been seen on cystoscopy to lie in the neighbourhood of the air-bubble or just behind this, there is always a possibility that it may have spread to the peritoneum, unless it is known to be small. The mobility of such growths and their relation to the abdominal wall can often be accurately estimated by pressure upon the latter during the cystoscopic examination, and this often helps to bring them into better view. If there is a doubt, and whenever the growth can be palpated bimanually, the following is the technique recommended. The peritoneum is opened down to its reflection from the bladder, and the peritoneal surface is carefully examined. Occasionally omentum is adherent and can be resected, and rarely the small intestine is also involved. Such growths are sometimes inoperable, but every endeavour should be made to excise them if possible, removing if necessary a large part of the bladder and the peritoneal covering where it is affected. For this purpose the abdominal and pelvic organs are first carefully packed off. An incision is then made around the peritoneal aspect of the growth at a distance of about 1 inch. Outside this the peritoneum is widely stripped from the bladder until it is sufficiently mobilized to permit closure. When this has been completed, the incision around the growth is continued through the bladder-wall, and the growth, together with 1 inch of surrounding healthy tissue, is removed. The bladder-wall should be caught by sutures or long tissue-forceps ; otherwise it retracts too much. Any fluid which may have been in the bladder is aspirated through a sucker. A self-retaining retractor (Fig. 990) is now inserted into the bladder, the incision being enlarged if necessary. The bladder cavity is examined and, if found free of other growths, the bladder is closed round a suitable drainage-tube by interrupted sutures of No. 1 plain catgut. If hæmorrhage has been well controlled, one of the self-retaining varieties of tube, size 36 Charrière (22 English) is used. The peritoneum is closed with a continuous suture. The abdominal wall is closed as described on p. 1986, a piece of corrugated rubber or a small drainage-tube being inserted into the prevesical space.

If the growth has not extended beyond the bladder-wall, the peritoneum is separated by blunt-pointed scissors, and closed when the viscus is sufficiently cleared. If the peritoneum is not formally but accidentally opened during stripping, it should be closed by suture or ligature but before this is done the opportunity should be taken to palpate for enlarged glands in the region of the internal iliac vessels. The bladder is now opened. Although this is most easily done in the midline anteriorly, the incision should be made so as to avoid cutting into the growth and in a part which provides easiest access to it. The edges of the opening are held up by stay-sutures, and the growth is inspected from within, a self-retaining bladder retractor often facilitating this. The incision is then extended through the bladder-wall to surround the growth at a distance of 1 inch from its margin, and the tumour is thus removed. The interior of the bladder should be carefully examined to exclude other growths. The bladder and the abdominal wall are closed with drainage as described on page 1985.

2. **Growths affecting the middle zone of the bladder.**—The growth may be on the posterior, lateral or anterior wall. The latter position, though rare, is of great importance for, in the male particularly, this part of the bladder and that immediately in front of the internal meatus cannot always be seen through the ordinary cystoscope, while if the growth is a little higher up, the usual bladder incision will be likely to cut into it. A growth originating in this wall of the bladder, if infiltrating, characteristically spreads widely in the prevesical space, soon becoming adherent to the anterior abdominal wall, and therefore requires very wide resection. Its position, cystoscopic appearance, particularly through a retrograde telescope, and fixity, on bimanual examination, will make this apparent. Further information will be gained during the operation. Every endeavour should be made to effect resection, as the results obtained are not unfavourable. If, however, the recti muscles themselves are involved, this is impracticable. When the growth is situated on the posterior wall and of considerable size the surgeon must open the peritoneum to learn if it is involved. If so, the affected portion must be resected, and the peritoneal cavity closed as previously described. If such extension is ruled out, or if the growth is on the lateral wall, the peritoneum is stripped from the bladder sufficiently to give a good exposure of the involved part of the viscus. As this dissection is carried down into the pelvis any extension of the growth becomes apparent, and occasionally enlarged glands are discovered.

The bladder, having been thus mobilized, is opened and self-retaining retractors are introduced. The growth is encircled by an incision at a distance of an inch from its margin. When carrying this through the thickness of the bladder-wall the surgeon should remember that the extent of an infiltrating growth is greater in the muscle coats than might be expected from the appearance on the mucosal aspect. The cutting can be done with a diathermy needle, curved scissors, or knife. As the excision proceeds, large vessels are divided ; these are picked up with long pressure-forceps and ligatured at once, or secured by sutures. Since the presence of many forceps obscures the view, stay-sutures are inserted at intervals. When the resection is completed, the bladder and the abdominal wall are dealt with as already described, a drainage-tube being left in the prevesical space.

3. **Growths affecting the base of the bladder.**—These are the most difficult with which to deal. Partial cystectomy cannot be undertaken if the growth involves both ureters, or the internal urinary meatus. A few small malignant papillomata in the latter position do not, however, preclude it, as they can be separately destroyed by diathermy coagulation. Although the line of excision can be carried right down to the internal meatus, it cannot go farther in this direction, and the surgeon should determine by cystoscopy that there is sufficient healthy mucosa at the lower edge of the growth to make the operation practicable. There need be no hesitation in excising a portion of the prostate together with an overlying growth.

The affected side of the bladder is first widely exposed from without and then opened. When this has been done a self-retaining retractor is inserted ; if this is not one of the illuminated patterns (Figs. 1007 and 1008, p. 2062), a good overhead light, or a head-lamp is essential. If the growth is situated close to but does not obscure one of the ureters, a thick catheter or bougie should be passed along the ureter and left in position during the operation. In many cases, however, the duct is involved and its opening obscured, so that this is impossible. An incision is made encircling the growth at a distance of one inch from it, but often such a margin will not be available on the side nearest to the internal meatus. It is well to begin the excision here, for if this part is left to the last, the blood running down will greatly obscure the view. If the growth is large, it is sometimes desirable to split the side of the bladder down towards the growth and then encircle it. In either case the incision is carried through all the coats of the bladder. Bleeding is often profuse, and the vessels are clipped with long pressure forceps and tied, or secured by transfixing suture. Occasional stay-sutures are useful to lift the bladder towards the surface. The growth is gradually completely surrounded and detached from the bladder. Often the bladder has by now contracted to a surprising degree, but this will not interfere with its future capacity as it is capable of subsequent distension. The site of excision is repaired with interrupted sutures, and, where convenient, the knots should be tied on the outer aspect of the bladder-wall. If a ureteric catheter has been placed in position it is now withdrawn and the original incision in the bladder closed round a tube as already described. A drainage-tube ⅜ in. in diameter is placed outside the bladder down to the bottom of the pelvis, being brought out alongside the suprapubic bladder drainage-tube.

Re-implantation of a ureter.—When a ureter or ureteric orifice is involved in an infiltrating neoplasm, the former is almost always dilated. This fact, which can often be ascertained before operation by excretion urography, is helpful to the operator, for in many cases it is not until the growth has been entirely detached from the rest of the bladder that the ureter is discovered, although then it can almost invariably be recognized if dissection is deliberate and a good exposure is obtained. When found, it is cut across about half an inch from growth, and the upper end is at once transfixed; to ensure that it is not lost, with a suture of fine catgut passed from within its lumen outwards. This is not tied, but caught in a pair of small pressure forceps, and temporarily held aside.

The growth having been removed, the wound in the bladder is sutured, beginning at that part which is nearest to the internal meatus. It will facilitate matters if, as sutures are inserted and tied, they are cut in series, the last inserted being clipped with pressure forceps and used to lift up the bladder towards the surface. When the lower part of the bladder-wound has been repaired to an extent sufficient to enable the ureter to be brought towards its new position without undue tension, it should be re-implanted as follows. Two stitches are necessary, unless it is much dilated, in which case three may be used; the catgut already holding the ureter can be rethreaded and used as one suture. The stitches need only attach the duct to the bladder mucosa unless there is considerable tension, in which case they must include some of the musculature.* The next suture which is used to repair the bladder-wall should be not less than half an inch from the site of implantation, in order to avoid compression of the ureter. In the rare instances in which the cut end of the ureter is lost, all that can be done is to place a drainage-tube through the wall to the interior of the bladder. In some such cases the kidney has by this means been preserved, but it is probable that if this accident happens the kidney above will become infected and dilated, and ultimately nephrectomy will be necessary. The remaining steps of the operation are as already described.

After-treatment.—If a considerable amount of blood has been lost, blood-transfusion is of great value. In other respects the after-treatment is that of other bladder operations. The vesical tube is irrigated once or twice daily and usually removed after 10–14 days. The drainage-tube which has been placed outside the bladder is left in position for 48 hours, and is then withdrawn sufficiently to cut off about an inch. Subsequently it is shortened daily, until at the end of a week or ten days the remainder is removed. The follow-up of these cases is important, and cystoscopy should be carried out within three months, and again at three- or six-monthly intervals for some years.

Neoplastic recurrences in the cystotomy scar.—A growth, which is definitely malignant, may develop in the bladder incision or between this and the abdominal wall, following an operation for a papilloma, even when apparently benign. If so, it takes the form of an infiltrating growth, the mucosal surface of which can be seen on cystoscopy and the mass felt on abdominal or bimanual examination. When not too large, such a tumour should be excised. The abdominal wall is opened above it and the whole of the bladder-wall involved, together with the peritoneum if necessary, is freed from the posterior aspect of the symphysis pubis and excised. Bladder drainage is provided.

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* See also p. 1965.

If the mass is too large for such operative treatment, radon seeds may be embedded through the abdominal wall, or some other form of irradiation may be tried.

2. RADIUM TREATMENT OF BLADDER GROWTHS

This may be applied endoscopically or after cystotomy.

Cystoscopic implantation of radon seeds.—This method is very useful in the treatment of malignant papillomata which are judged unsuitable for resection on account of their position. Even when both ureters are surrounded, growths can be safely treated, one at a time, for though a temporary blockage of the duct may result there will probably be no permanent contracture. Sessile and widespread papillomata are well treated by this means, as are also growths which are just too large for cystoscopic diathermy. Implantation of seeds can be used in aged or feeble patients whose condition makes them unsuited for open methods of treatment, but who have growths too large for transurethral diathermy. It may be employed where hæmorrhage is considerable though not severe enough to require cystotomy, for an experienced cystoscopist will usually be able to obtain a sufficient view of the growth for the rapid implantation of seeds. If this can be effected, hæmorrhage will in most cases be arrested within twenty-four hours, and a further opportunity will be obtained for deciding on the best form of treatment. The cystoscopic method has the advantage that the bladder is not opened and, if treatment is incomplete, as indeed is often the case, it can be repeated without causing the patient undue discomfort. This method is not suitable for growths situated low down on the anterior bladder-wall, as this region is almost always inaccessible. Growths at the apex of the bladder are also difficult to reach, but can sometimes be brought into position by manual pressure on the hypogastrium. Growths at the internal meatus are usually unsuitable, and if seeds have to be implanted here this must be done through a panendoscope. For infiltrating growths the method is of less value, though sometimes the immediate effect is extremely good, causing the vesical surface of the growth to disappear. Seeds may also be used to effect a temporary arrest of hæmorrhage.

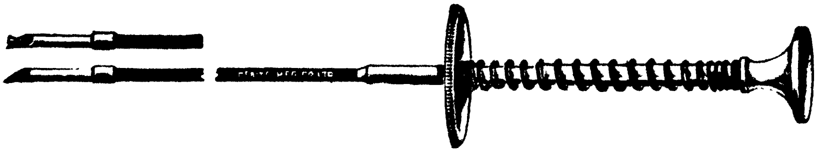

Fig. 991.—Ogier Ward's radon seed implanter.

Technique.—The radon seeds used have a filtration case of platinum or gold, the thickness being 0.3 mm., and one end of this case is slightly pointed. The length is 0.6 mm. and the content varies from 1 to 2.5 millicuries, 1.7 mc. being usually employed. The seed is placed in a suitable introducer. My own pattern is illustrated in Fig. 991, which shows the hollow end and the piston. The point is dipped into sterile vaseline before the seed is inserted, thus preventing it from dropping out. A flushing cystoscope is essential, and for growths of the trigone a panendoscope is particularly suitable. The patient is given either a low spinal or a general anæsthetic, and is placed in the lithotomy position.

If the base of the tumour is visible the seeds are implanted into this part first. The introducer is passed through the cystoscope and by means of the Albarran lever is brought into position and the end is thrust into the mucosa sufficiently to bury the whole point. The seed is discharged by compression of the handle, which moves forward the piston in the hollow needle. The introducer is then withdrawn and handed to an assistant to be reloaded. It is convenient to work with two introducers. Bleeding is inevitable, and may seriously interfere with implantation which, to be effective, must be accurate, but usually it is possible by flushing to maintain a sufficiently clear medium round the growth. The introducer shown in Fig. 991 is itself a diathermy electrode which can be attached to a lead. By this means the tissues immediately around each stab of the needle can be coagulated before the seed is placed in position, thus considerably lessening hæmorrhage. It can also be used to coagulate a bleeding-point.

If there is œdema or if there are secondary nodules of growth in the region of the base of the tumour, seeds should be planted in this area. When the papilloma is sessile or when the base cannot be seen, seeds are implanted directly into it ; it is in this type of case that hæmorrhage is most severe. At any one treatment only the surface of the tumour nearest to the operator can be treated. As many as twenty seeds may be used at one session ; more commonly ten is sufficient, but a reserve is desirable as some are likely to be so imperfectly implanted that they drop out ; if this occurs they can often be seen lying upon the bladder base. At the end of the operation the bladder is not washed out, nor is a catheter placed in position. The patient should be kept in bed for four or five days, and can then be discharged from the institution with instructions to return for cystoscopy in a month's time. Any small tumour which has been treated will then be found to be entirely necrotic, though not necessarily separated from the bladder-wall, a process which may not be effected for some months. During this time the necrotic tissue not infrequently becomes coated with a phosphatic cap which can sometimes be detached by brushing with a diathermy electrode ; it is quite soft, breaks off readily, and is easily passed. I know of only two cases in which calculus formation has resulted, and one of these occurred in a patient who, before the introduction of radon seeds, had already formed several vesical calculi. Lithotomy was necessary in this instance ; in the other the minute calculus was removed through a cystoscope. In both cases a radon seed was found in the centre, forming a nucleus. This complication, however, is quite rare and should not be considered as a contra-indication. The majority of the seeds, including those imperfectly placed in the first instance, are passed in the urine; occasionally one or two can be seen months or years afterwards lying harmlessly beneath the mucosa. Radium burns sometimes occur, but they are never severe, and although an ulcer may be seen on cystoscopy, it rarely causes the patient any inconvenience, and any cystitis which accompanies it is usually mild and not of long duration.

Larger tumours treated by this means will be found to have been in part destroyed, exposing portions which were hitherto hidden from view. It will not usually be desirable at the first subsequent cystoscopy, one month after treatment, to do anything further, for the full effects of the irradiation will not yet be apparent. Cystoscopy should be repeated at monthly intervals until it is obvious how much of the growth is still unaffected. A further series of radon seeds may then be implanted.

Cystotomy and implantation of radium.—Radium can be used in this manner for growths which cannot be treated by any other means, particularly infiltrating ones.* Either radium needles or radon seeds can be employed. If radium needles are used they should have a strength of 0.5 mg. or 1 mg. R.A., and be screened with 1 mm. of platinum. The most convenient lengths are 1 cm. and 2 cm. If practicable, the bladder should be to some extent mobilized and opened, so that both the mucosal and extravesical aspects of the growth are accessible. Needles are implanted at a distance of 1 cm. from each other, and should be placed not only into both aspects of the growth, but also to irradiate the tissues around. This having been done, the bladder is sutured round a straight drainage-tube, the threads of the needles being brought out alongside this and tied together. The tube, together with the needles, is removed at the end of about five days, and a smaller tube is put in its place. This form of treatment has the grave disadvantage that often the needles do not remain in position but, becoming loosened, fall into the bladder cavity. Also prolonged sepsis commonly results, and very often a serious radium burn of the bladder-wall which may cause great pain, and often takes many months to heal, during which time the cystostomy must be kept open.

As an alternative, radon seeds may be used. These are of the same strength as those used for cystoscopic implantation, but are screened with 0.5 mm. of platinum or gold. When radium is used in this form there is the advantage that, after an in-dwelling catheter has been put in position, the bladder can be closed, unless sepsis or hæmorrhage is too severe. A drain is placed through the lower part of the abdominal incision in case of leakage.

Growths originating in the anterior wall of the bladder which have extended into the prevesical space and are adherent to the inner aspect of the anterior abdominal wall, and which are too extensive for excision, can sometimes be effectively treated by radon seeds, the growth being much reduced in size by this means and the vesical symptoms alleviated. This is done without opening the abdomen.

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* Durden Smith, "The Use of Radium in Carcinoma of the Bladder," *Brit. Med. Journ.*, Sept. 1934, ii, 584.

A long introducer is used and is thrust through the skin downwards and forwards immediately above the symphysis pubis. Seeds are placed both in the middle line and at either side, being arranged to irradiate widely the affected region, about twenty being used. A precise estimate of the proximity of those placed nearest to the bladder mucosa can be obtained by watching through a cystoscope the movements of this part when the introducer pushes against it.

3. TOTAL CYSTECTOMY

Indications.—(*a*) Papillomatous disease of the bladder which is too extensive for treatment by any other means. (*b*) Malignant growths, whether papillomatous or infiltrating, which cannot be treated by any of the measures described in the preceding paragraphs, and which are confined to the cavity of the bladder or have not extended so far outside its wall that mobilization and removal are impossible, and which have not given rise to metastases.

Before total cystectomy the urine must be diverted from the bladder. This can best be achieved by transplanting the ureters into the bowel (*see* p. 1966). In certain cases they may be brought on to the surface of the skin, but the results are not satisfactory owing to the difficulty of collecting the urine.

Preliminary cystoscopy must be carried out under anæsthesia and must prove beyond doubt that total cystectomy can provide relief. Some surgeons advise that for this purpose the bladder should be opened and the growths inspected before the ureters are transplanted. Transplantation of the ureters should not be undertaken unless there is a reasonable probability of proceeding to the operation of total cystectomy, for, although the diversion of the urine may give some relief, the growth within the bladder maintains hæmorrhage, sepsis and vesical irritability which is likely to keep the patient in a state of continued misery. If total cystectomy is to be undertaken two operations are usually required. At the first both ureters may be implanted into the bowel, and at the second the bladder may be excised, or alternatively one ureter is transplanted at the first operation and at the subsequent operation the second ureter is transplanted and the bladder excised. In some instances bilateral transplantation of the ureters and total cystectomy have been performed at one operation.

Preliminary investigations of the kidneys should include a determination of function by blood-urea estimation and excretion urograms; the latter, in addition to giving an accurate indication of infection, will reveal the condition of the ureters. Dilatation of the ureter is almost always present wherever a ureteric orifice is surrounded by growth, and may be accompanied by hydronephrosis. Such dilatation is not a contra-indication to transplantation but, if both ureters and both kidneys are affected and if there is reason to suspect severe renal infection, it is unlikely that the patient will survive the operation. Temporary nephrostomy, either unilateral or bilateral, preceding the transplantation, may sometimes make the operation justifiable, and if renal fistulæ are established in this manner they should not be allowed to close until the patient is fully recovered from all operations. The interval between transplantation of the ureters and excision of the bladder should not be less than three weeks. It may be desirable to wait longer, but the sooner the operation is undertaken the better, since the patient's sufferings will persist, and sepsis in the bladder cavity may require daily irrigations which are often very painful.

Total cystectomy by extraperitoneal operation.—The bladder is washed out and left empty. The midline sub-umbilical incision, through which the transplantation of the ureter was performed, is re-opened. If there is a fistula this is excised, or if the bladder had been opened for preliminary examination, this portion of the parietal scar is removed. A transverse incision may be employed with division of sufficient of the recti and their sheaths to give adequate access to the bladder. In either case care is taken not to open the peritoneum, which is stripped from the sides and upper aspect of the bladder, and then from its posterior surface down to the rectum. This process is sometimes made easier by a moderate degree of vesical distension but, when completed, any fluid in the bladder adds to the difficulties of the operation, and it should therefore be removed by catheter. The bladder is then lifted forwards to enable the dissection to be continued downwards in order to separate the seminal vesicles and the prostate from the rectum, care being taken not to open the latter. As the lateral aspects of the bladder are cleared, its main blood-vessels are clamped and ligatured and the vasa are divided. The bladder is next stripped from the symphysis pubis, thus bringing into view in the male the anterior aspect of the prostate. This is freed down to the urethra which, if necessary, can be made more obvious by the passage of a stiff catheter. The canal is closed by a cholecystectomy clamp, ligatured, and then divided. If the prostate is known to be free of growth, not all of it need be removed, and it can therefore be cut across, together with the prostatic urethra. The bladder, with the whole or part of the prostate, and preferably with a clamp on the urethra at the apex of the gland, is next lifted upwards and backwards and, having been completely freed by dissection from below, it is removed. Drainage is provided by a tube leading from the bottom of the pelvic cavity or by a catheter passed through the divided urethra.

Total cystectomy by a transperitoneal operation.—This method must be employed if any portion of the peritoneum is involved by extension of the growth, but it may be chosen as easier, though occasionally adhesions resulting from the operation upon the ureters may cause difficulty. After the peritoneum has been opened, an incision is made around that portion of it which surrounds the upper and posterior parts of the bladder, which are then exposed. The rectum is dissected from the base of the bladder and from the seminal vesicles and prostate. The blood-vessels and vasa are divided and the bladder is pulled backwards to expose the urethra at the apex of the prostate. The remainder of the operation is as described in the preceding paragraph. When this method is employed the bladder should be empty. In a few cases it may be possible to divide the prostate above the verumontanum, and leave the whole of the genital tract intact. There may be difficulty in closing the peritoneum, and a wide dissection from the lateral wall may be necessary.[*]

In the female total cystectomy is difficult if the vagina is involved, and it is therefore necessary to remove a portion of its wall. In such cases drainage is best provided by a tube leading from the pelvic cavity out through the vagina.

Results.—Patients suffering from inoperable growths of the bladder are poor subjects for extensive surgery. The transplantation of ureters into the bowel, however carefully performed, is much more dangerous in the presence of a malignant growth than when undertaken for a congenital abnormality such as ectopia vesicæ. The age of the patient, the deterioration in health, the presence of infection, and the fact that at least one of the ureters is usually dilated, with damage to the kidney, adds greatly to the dangers of this severe operation. If, however, the patient recovers and improves in general condition the subsequent operation of total cystectomy is a less severe ordeal. The following shows some of the results which have been obtained :

K. Scheele[†], in cases collected from literature, reports 43 one-stage operations with a mortality of 53.5 per cent., 17 two-stage operations with a mortality of 29.4 per cent. ; E. Beer[‡] 8 cases : operation mortality, 1 death ; R. C. Coffey[||] 13 cases : operation mortality, 1 death ; B. Ward[§] 7 cases : operation mortality, nil ; Hyman[¶] 19 cases : operation mortality, 21 per cent. He recommends cutaneous ureterostomy. From the Mayo Clinic in 1941 eleven cases of total cystectomy were reported without a death.

Those who survive the complete treatment are greatly benefited thereby, since they are spared an early death preceded by a period of intense distress ; this entirely justifies the operation, though in some patients the treatment of the disease is incomplete, inasmuch as metastases in glands and elsewhere cannot be eradicated. In Bernard Ward's series of seven cases one lived for five years and another for three. In Hyman's series some patients survived for 5 to 9 years.

OPERATION FOR DIVERTICULUM OF THE BLADDER

Preliminary examination and treatment.—The diagnosis of a diverticulum is made by cystoscopy combined with cystography. On cystoscopy the number of diverticula and their position should be carefully noted because it is sometimes difficult to locate their orifices when the bladder has been opened. Both ureters should be identified, to ascertain the relationship of the ureteric orifices to that of the diverticulum and to ensure that neither opens into the sac. Cystoscopy also affords an opportunity of exploring the urethra for stricture, and of ascertaining if there is any enlargement of the prostate. Minor degrees of change in this gland or the existence of Marion's disease at the vesical neck may, by obstructing the out-flow of the bladder, lead to the formation of a diverticulum, and operative treatment is incomplete unless this factor is also dealt with. Posterior urethroscopy is necessary in some cases to decide this point.

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[*] R. C. Coffey, " Transplantation of the Ureters into the Large Intestine," *Brit. Journ. Urol.*, Dec. 1931, iii, 353. H. Wade, " Vesical Exclusion," *Proc. Roy. Soc. Med.*, Oct. 1937, xxxi, 277.

[†] *Z. Urol.*, 1923, xvii, 65

[‡] *Amer. J. Surg.*, 1929, xc, 864.

[||] *Urol. Cutan. Rev.*, 1933 xxxvii, 723.

[§] *Proc. Roy. Soc. Med.*, 1936, xx, 1.

[¶] *Amer. Journ. Surg.*, 1935, xxviii, 5.

Cystography is carried out by passing a catheter to empty the bladder and then filling it with a solution of 10 per cent. sodium iodide ; about half a pint is usually sufficient. Anterior, posterior, half lateral and, if possible, lateral views, are then taken ; these will show the shadow of the bladder and of the sac. The catheter is then withdrawn and the patient passes as much urine as possible. Another X-ray is taken and shows the sac still filled and the amount of residual urine in the bladder. The catheter is passed, the bladder emptied, and a third X-ray is taken ; this shows the volume of solution left in the sac which cannot be withdrawn even by catheterization, and this is called "concealed residual urine" (Joly). Excretion urograms are also useful, for they give similar information and demonstrate dilatation of one or other ureter, which is often present, together with any renal change.

A full examination of the urine should be made, since vesical infection is common. Renal infection may also be present, but is not usually sufficiently serious to contra-indicate operative treatment. Renal function should be determined. When infection is present a short course of bladder lavage may be carried out, but in most cases the results from this are unsatisfactory, as the diverticulum cannot be cleansed. Preliminary cystostomy may occasionally be necessary in very septic cases. If it is performed, two small tubes should be introduced through the wound into the depths of the diverticulum and stitched to its orifice ; these are in addition to the usual cystostomy tube. Washing of the sac can be carried out through one of these, the other acting as an out-flow. Such preliminary treatment should, however, be avoided if possible, as diverticulectomy is made more difficult by pre-existing abdominal incision and the adhesions between the bladder and abdominal wall which inevitably result. Catheter drainage of the bladder may be necessary to restore impaired renal function, but should be as brief as possible, because in clean cases it may lead to infection, and in septic cases cleansing by this means is necessarily incomplete. Diuretics and urinary antiseptics should be prescribed.

Technique.—If a diverticulum is large enough for any operation upon it to be necessary, this should always take the form of diverticulectomy. It is useless to attempt less than this, and such a method as enlarging the orifice of the sac into the bladder is without benefit. Diverticula have no power of contracture and when the patient micturates a portion of the urine flows out through the urethra and the remainder flows into the sac. Occasionally, on account of the patient's feeble condition, treatment may have to be limited to the removal of a stone from the bladder or from the sac, the neck of which may have to be incised, but such limited procedures are not followed by permanent improvement and further calculus-formation is to be expected. The technique for removal varies with the size and position of the sac.

Excision of small diverticula.—The bladder is exposed as for cystotomy (p. 1981) through a 5-inch incision in the abdominal wall. A 3-inch incision is then made in the bladder-wall, a self-retaining retractor is introduced—one of the illuminated patterns being very useful—and the orifice of the diverticulum is located. The lip of the opening is held with dissecting-forceps and the mucosa incised immediately outside the margin for the whole of its circumference. The incision is deepened to include the muscular coat. With the aid of dissecting- or long pressure-forceps, the orifice of the sac is lifted up into the bladder, while the tissues immediately surrounding the neck are dissected with long curved scissors. By this means the outer surface of the diverticulum begins to appear through the opening and the dissection is continued until the whole of it is drawn into the bladder. A finger introduced into the diverticulum may sometimes be necessary to facilitate this. The dissection should be kept close to the wall of the diverticulum and, if this is done, the peritoneum, the vas, and the ureter are unlikely to be injured. If the urine is aseptic and if the space left after the removal of the diverticulum is small and hæmorrhage therefrom slight, the wound in the bladder-wall from which the sac has been resected may be closed with interrupted sutures of No. 1 catgut. But if these conditions do not obtain, it is better to leave a narrow piece of corrugated rubber extending from the depths out of which the diverticulum has been removed through the abdominal incision. The bladder and abdominal wounds are closed as after cystotomy around a suitable tube. More than one diverticulum can be dealt with in this fashion. The treatment of obstruction at the bladder outlet is discussed later.

Excision of large diverticula.—The bladder is distended with 8 oz. of oxycyanide of mercury solution and the patient placed in the Trendelenburg position. A midline abdominal incision is made extending upwards from the symphysis pubis for five inches. The bladder is cleared by dissection with the fingers on the side from which the diverticulum takes origin, the hand passing down towards the bottom of the pelvis and pushing the peritoneum upwards. In this way the bladder is mobilized and a considerable portion of the sac is cleared. When as much as possible has been effected in this manner, the bladder is opened by a small incision through the vault and the fluid withdrawn by a sucker. This incision is then prolonged down the lateral aspect of the bladder towards the orifice of the diverticulum. A self-retaining retractor, preferably illuminated, is then introduced to locate the opening more accurately. A sucker is now introduced into the cavity to empty the contents or the cavity may be swabbed dry. The incision is prolonged to within ⅛ in. of the orifice of the sac. (The preservation of the ureter, which is often closely related to the sac, is discussed later.) The incision is carried round the opening close to its margin and the neck of the sac is detached entirely from the bladder, which falls towards the opposite side of the pelvis. A finger is introduced into the diverticulum or one or more pairs of pressure forceps are attached to its margin in order to make the sac tense. A dissection, partly with scissors and partly with gauze, is continued until the whole sac is freed. Adhesions are often very dense in the most inaccessible parts, namely in the region of the ischial spine. The process is facilitated if the dissection is kept close to the lining wall. Not infrequently the sac is accidentally opened at some point, and rarely it may be necessary to leave a small portion of it behind in the bottom of the pelvis, but no harm results from this. Hæmorrhage is not usually severe and is controlled by the use of long pressure forceps. The incision in the bladder-wall is closed with interrupted sutures as in any other partial cystectomy, care being taken not to compress the ureter. Drainage of the bladder is provided by a suitable tube, e.g. White 36 Charrière (22 English), and a tube about ⅜ in. diameter, brought out alongside this, drains the paravesical space from the bottom of the pelvis.

Difficulties and dangers. 1. **Adhesions.**—All sacs except the smallest are adherent to structures outside the bladder, particularly if infection is present. For this reason no attempts should be made to invaginate any but the very smallest by tissue forceps or a sucker introduced into the cavity, as there is a serious risk of pulling on the peritoneum. Loops of intestine have even been injured in this way. For very large diverticula it may, in rare instances, be necessary to open the peritoneal cavity.

2. **Sepsis.**—Every endeavour should be made to reduce sepsis before operation but, even when this is impossible, severe bladder sepsis is no contra-indication to operation, and the results are usually very satisfactory if adequate bladder-drainage is provided after operation.

3. **Calculus.**—This is a frequent complication, stones being found in the bladder and in the diverticulum. They are removed at the diverticulectomy. It may be necessary to enlarge the neck of the sac to remove a stone within it.

4. **Neoplasms.**—A papilloma or infiltrating growth may be associated with a diverticulum, being situated either at its orifice or inside the sac. A papilloma in the first situation is dealt with by diathermy through a cystoscope before operation, or is coagulated at the diverticulectomy. A growth within the sac is excised with it unless its extent renders this impossible.

5. **The ureters.**—The ureter is in close relationship to any diverticulum which takes origin from the lower zone of the bladder. The commonest position for the opening of a diverticulum is slightly

posterior to that of the ureteric orifice. From this the sac descends into the depths of the pelvis and as it does so its neck hangs over the ureter as the latter passes towards the back and upper part of the pelvic cavity. The ureter, therefore, lies between the neck of the diverticulum and the lower part of the bladder-wall. It is often compressed here and dilated above this point. When such a relationship is anticipated, before commencing resection of the sac, a 10 French stiff ureteric bougie or catheter is passed under direct vision up the duct to the renal pelvis, and the assistant takes care that this remains in position throughout the operation. In many instances, although the relationship is so close, the ureter outside the bladder is not seen at any stage, but its position can always be determined by feeling for the bougie within it, and if by chance it should be divided or injured the latter forms a guide to its position and an aid to its repair. In some cases the ureteric orifice is at the lip of the diverticulum, and very careful dissection is then necessary. Rarely, the ureter opens into the diverticulum ; if so, when the sac has been excised the ureter must be re-implanted into the bladder-wall (*see* p. 2016).

6. **The vas.**—The vas is rarely seen if the dissection is kept close to the wall of the diverticulum. Occasionally it may be adherent, and sometimes it is necessary to divide it.

Treatment of associated obstruction to the bladder outflow.—A small proportion of diverticula are congenital. The ætiology of the remainder is undetermined, but it is certain that obstruction, either at the vesical neck or below, often plays an important part in their development, and the treatment of a diverticulum is incomplete unless this factor is also dealt with. Conversely, when once a diverticulum has formed, cure is impossible by merely treating the obstruction, for however complete this may be, a diverticulum remains without power to empty itself owing to the absence of musculature in its wall.

(*a*) **Stricture.**—Urethral strictures should be treated by dilatation or urethrotomy before diverticulectomy, and subsequent treatment is equally important.

(*b*) **Prostatic obstruction.**—In many cases an obviously enlarged prostate is associated with a diverticulum. If the patient's condition is good at the conclusion of the excision of the sac, and no evidence of renal insufficiency has been found, enucleation can be performed at the same operation. In many cases, however, it is best to leave this until the patient is fully recovered from the first operation, particularly if it has been necessary to transplant a ureter, or if sepsis is severe. Prostatectomy is then performed as a second operation. This order should never be reversed, for if the prostate is first removed, a succeeding diverticulectomy is more difficult on account of the scar-tissue which has formed in the abdominal wall and along the fistula, and persistent and severe bladder sepsis will almost certainly be present.

Minor degrees of prostatic obstruction can be very successfully dealt with by transurethral resection, performed about three weeks after diverticulectomy. It will be found that in some cases the suprapubic vesical fistula persists until this has been done, although the degree of prostatic obstruction is apparently very slight.*

Marion's disease, or stenosis of the vesical neck, which is one of the causes of the formation of a diverticulum, can be dealt with by operation through the bladder at the conclusion of the diverticulectomy if the patient's condition is satisfactory. In many instances, however, it will be desirable to postpone treatment, and in such cases this will usually take the form of perurethral resection, which should be carried out before any attempt has been made to allow the suprapubic fistula to close.

OPERATION FOR MARION'S DISEASE OF THE VESICAL NECK

The diagnosis of Marion's disease, also known as stenosis or dysectasia of the vesical neck, is difficult, since it may be due to a variety of pathological causes, and because the local condition is not easy to recognize. Marion describes two forms, congenital and acquired.

In the *congenital form* the complications appear early in infancy. Micturition is slow and the child has to strain, often leaving residual urine in the bladder. Complete retention may occur. It is important to distinguish between this condition in an infant and obstruction due to congenital valves in the posterior urethra. The symptoms may develop rapidly or gradually, and in some cases it may not be until as late as the fiftieth year that the patient presents himself for treatment.

In the *acquired type* the symptoms are the same, but do not begin until later in life, frequently at about the age when prostatic obstruction may be expected. On investigation it is common to find evidence of longstanding chronic urethritis and perhaps stricture ; the dilatation of this does not, however, give free micturition.

Pathology.—The vesical neck may be affected by any of the following changes : 1. There may be congenital hypertrophy of the sphincter internus comparable with congenital hypertrophy of the pylorus in infants. 2. The sphincter internus becomes permeated by inflammatory tissue which may eventually lead to its complete fibrosis. 3. In addition to such fibrosis, glandular proliferation of an adenomatous type may be present.

Diagnosis.—Marion's disease should be suspected when no other cause of obstruction can be found. Its existence can be proved by :

1. The passage of a cysto-urethroscope which reveals the volume of residual urine. It also demonstrates that there is no enlargement of the prostate, as evidenced by a lengthening of the urethra above the verumontanum and an intravesical projection with a characteristic

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* Swift Joly, "Operative Treatment of Vesical Diverticula," *Lancet*, 1923, ii, 445.
Ogier Ward, "Fifty-three Cases of Vesical Diverticula," *Brit. Journ. Surg.*, 1938, xxv, No. 100, 790.

V-shaped notch on its anterior aspect. By careful inspection it should be possible to recognize the abnormally raised and rolled margin of the internal meatus.

2. A cystogram including the prostatic urethra. The exposure should be made at the moment when the patient is endeavouring to micturate. It will be seen that the internal meatus does not dilate to the normal extent and only an extremely fine column of fluid passes along it.

3. Cystotomy and inspection of the internal meatus, which will be seen to have an edge which is raised and rolled on all aspects.

4. Palpation of the internal meatus with a finger introduced through a cystotomy wound. It will be found indurated and very resistent to dilatation.

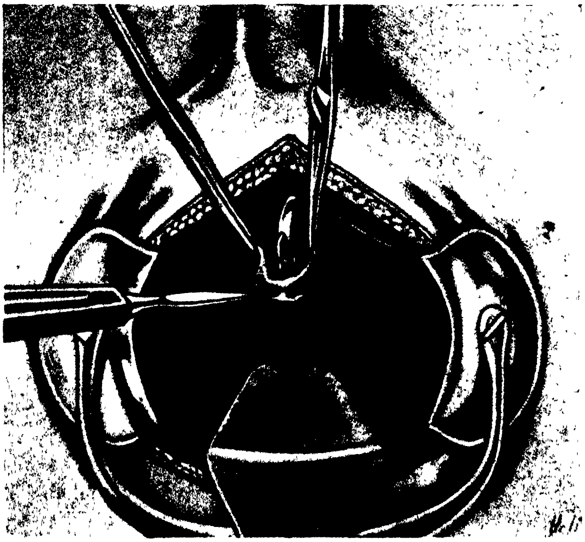

Fig. 992.—Marion's resection of the cervical neck.
From "Traité d'Urologie," p. 1043.

Treatment.—Marion * recommends in all cases the operation of **cystotomy and total resection of the vesical neck** since this is always followed by cure which lesser measures may not establish. He points out that approach by the suprapubic route gives an opportunity for dealing with any complications which may be present within the bladder, particularly for the excision of a vesical diverticulum, a not uncommon association of this disease.

After the bladder has been opened, the vesical neck is inspected and palpated and care is taken to exclude any benign enlargement of the prostate. A circular incision is made round the col vesicæ at a distance of about 1½ cm. from the opening of the urethra and to a depth of 1 cm. (Fig. 992). The col thus mobilized is lifted up with forceps and the dissection is continued with curved scissors to a depth of 2 cm. At this level the urethra is cut across transversely. The cavity thus produced is packed with fine ribbon gauze and the bladder closed around a self-retaining drainage tube of the de Pezzer type. The gauze is removed after forty-eight hours.

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* "Traité d'Urologie," 3rd Ed., p. 1043.

Although Marion considers it essential to excise the whole col in this manner, H. Harris * has described an operation for **partial excision with reconstruction of the vesical neck.** After the bladder has been opened, the internal meatus is forcibly dilated by a finger introduced through the cystotomy wound, while the prostate is supported by two fingers in the rectum. Two traction sutures are inserted, one on each side, about half-way round the dilated prostatic rim. For these and all subsequent sutures a boomerang needle and suture-carrier are desirable. Using these to steady the bladder neck, the great part of the posterior segment is excised by two lateral cuts made with a knife, and extending deep into the prostatic urethra, the piece of tissue thus mobilized being cut away with scissors. On either side, the lateral aspects of the vesical neck are undercut to permit retraction. One, or possibly two, deep hæmostatic sutures are inserted on each side behind the traction sutures and tend to diminish the raw surface. The bare area is finally covered in by a retrigonization-suture, and a catheter is placed in the urethra suspended by salmon-gut suture to a rod on the abdominal wall, as in Harris's operation for prostatectomy.

Perurethral methods are very effective in the treatment of this condition, and may take the form of cutting away portions of the posterior margin of the vesical neck with a Colling's knife, or, better, by means of a diathermy resectoscope. The amount of cutting performed must be strictly limited lest the perivesical tissues be laid open or the rectum injured.

OPERATIONS FOR FISTULA OF THE BLADDER

Vesico-vaginal Fistula

Vesico-vaginal fistula may follow an injury at childbirth, when it is often large, or an operation on the pelvic organs, in which case it is usually small, rarely bigger than 1 cm. in diameter. Occasionally it results from a burn, when radium has been used in the treatment of carcinoma of the cervix. This last condition is unsuitable for any local operation, and is best treated by transplantation of the ureters into the colon.

When the fistula is due to either of the first two conditions the vagina should be investigated through a speculum and by digital examination. The fistula is usually situated at its vault, and may be in the middle line or, more commonly, in one of the fornices. It may be very minute, a mere pin-point, or there may be a large aperture through which the interior of the bladder is visible. Occasionally the fistula extends into the urethra. Often considerable induration surrounds the opening, and this frequently frustrates attempts to repair it by an operation through the vagina. In the majority of cases, however, operation by the vaginal route suffices for cure (*see* p. 1842). The combined transvesical and vaginal method described below is reserved for cases in which previous vaginal operations have failed to produce a cure, or for those patients in whom the fistula is high up on the vault of the vagina, or is of unusually large size.

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* "Posterior Segmental Block-Excision of the Bladder-Neck with Primary Closure," *Brit Journ. Surg.*, July, 1935, xxiii, 45.

Cystoscopy should always be carried out, and the opening into the bladder, even if only a small one, can thereby be located. In case of larger openings a tight pack must first be placed in the vagina to allow distension of the bladder. Cystoscopy also distinguishes a vesico-vaginal from a uretero-vaginal fistula ; occasionally both are present. The urine is usually infected, and bladder and vaginal lavage is carried out for a few days before the operation.

Operative treatment has for its object the removal of scar tissue, the separation of the bladder from the vaginal wall, and the separate suture of each layer. The patient is placed in the Trendelenburg position and the bladder is opened through a 4-inch suprapubic incision. Self-retaining retractors are introduced and the region of the fistula is inspected and palpated. An incision is made round this, clear of all induration in the bladder-wall, usually at a distance of about ½ in. from the fistula. The incision is carried through the muscular wall of the bladder until the cellular tissue between it and the vaginal wall is exposed. The bladder-wall is then undercut with curved Mayo scissors to free it from the vagina to such an extent as to enable the fresh edges to be drawn together without tension. A dissection of ½–1 in. is usually sufficient, but this depends on the size of the fistula and amount of induration present. The opening in the wall of the bladder is closed by a continuous suture or by interrupted sutures of No. 1 plain catgut. The bladder and abdominal walls are closed round a drainage tube of the de Pezzer type of about 28 Charrière (17 English) size.

The patient is now placed in the lithotomy position and a weighted vaginal retractor is inserted. The vaginal orifice of the fistula, together with the indurated tissue around it, is resected with a knife and curved scissors. There should be no risk of injuring the bladder-wall if this has been suitably mobilized during the first part of the operation. The resulting aperture in the vaginal wall is closed with interrupted sutures of No. 2 catgut, and a very light packing of gauze is left in position. The after-treatment is as for other cases of cystotomy (p. 1984). At the end of ten days the bladder-tube is removed and the suprapubic fistula closes spontaneously ; occasionally an in-dwelling catheter is required to hasten this.

Very large fistulæ, such as occasionally result from injuries at childbirth, may require a more extensive operation. For these Swift Joly advises the following procedure :

Transperitoneal operation.—A catheter is first passed to make sure that the bladder is completely empty. A vertical median incision is made from the pubis to the umbilicus. The peritoneal cavity is opened. The patient is placed in a moderate Trendelenburg position, and the intestines are packed off. The apex of the bladder is defined. The bladder is opened at this point, and the incision through the bladder-wall is carried backwards from this until the vault of the vagina is reached. The vagina is not opened. Two stay-sutures are inserted on each side of the bladder-incision, to serve as retractors. By this means a very wide exposure of the fistula is obtained, and also it can be brought up almost to the surface.

The fistula will now be seen a short distance below the posterior end of the bladder-incision. The latter is continued down to the fistula, and then round it as a racquet, but not through the vaginal wall. The bladder is separated from the vagina for at least 1 cm. on either side of this terminal portion of the incision, and for a similar distance round the fistula. The vaginal opening of the fistula is closed by a continuous catgut suture, taking care to bring as much as possible of the raw surfaces of the vaginal wall into apposition. This is done by passing the needle obliquely through the wall of the vagina (Fig. 993 (1)). The next step is to place from one to three mattress-sutures transversely from the angle between the bladder and vagina on one side to a corresponding point on the opposite side (Fig. 993 (2)). These sutures are put in to avoid leaving an open space between the bladder and vagina ; this is an important step in the operation, but one which may be very difficult. The edges of the bladder-incision now lie together, and have a tendency to become invaginated into the bladder. They are united by a through-and-through continuous suture (Fig. 993 (3)), commencing at the posterior angle and continued forwards until the apex of the bladder is reached, where space is left for the insertion of a self-retaining suprapubic tube of the de Pezzer type. A continuous Lembert suture is passed through the peritoneum over the bladder-incision, taking care that no raw area is left where the bladder joins the vagina. This line of sutures is continued up to the apex of the bladder, and ends just behind the suprapubic tube, which lies entirely outside the peritoneum. The abdominal incision is closed without drainage.

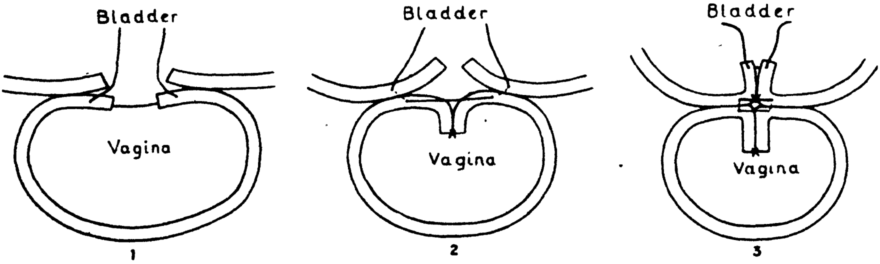

Fig. 993.—Swift Joly's operation for vesico-vaginal fistula. Application of sutures.

After-treatment.—The suprapubic tube is kept in place for a fortnight, in order to give the bladder time to heal. Care must be taken that it does not become blocked or kinked. The bladder should be gently washed out every day. At the end of the fortnight the tube is removed, and a self-retaining catheter is inserted through the urethra and left in position till the suprapubic sinus has closed. In this way the abdominal wound is kept dry during the whole of the convalescence.

The success of the operation depends on the accurate suturing of the bladder-wall. The vaginal suture is not so important, but is necessary to eliminate any weak spot which may subsequently give way, and to provide support for the base of the bladder. The mattress-sutures are inserted to prevent formation of a cavity between the bladder and vagina.

This operation is most suitable for cases of vesico-vaginal fistula following hysterectomy. It can be performed when the fistula follows childbirth, provided the fistula does not involve the internal meatus, but is then much more difficult, as the dissection of the bladder from the vagina is much more extensive, and has to be carried out at a greater depth. In these cases the uterus tends to get in the way. A stay-suture should be passed through it, and tied to the abdominal retractor. This puts the vagina on the stretch and facilitates the dissection of the bladder from it.

Legueu * describes a somewhat similar operation. He opens both the bladder and vagina through a laparotomy incision, separates one from the other and closes them separately. He then brings down a flap of peritoneum between the two organs. He makes no provision for bladder-drainage after the operation, which seems essential.

When a vesico-vaginal fistula is so extensive that the bladder sphincters are involved, treatment may take the form either of transplantation of the ureters into the colon or, if it is possible to effect a complete repair of the fistula, Marion's operation for reconstruction of the urethra in the female (*see* p. 2036).

Entero-vesical Fistulæ

Fistulæ between the bladder and small intestine are rare, and are usually the result of gunshot wounds, swallowed foreign bodies, or typhoid fever. In treating them a temporary cystostomy should be performed and followed by laparotomy, with the object of separating the intestine from the bladder and repairing both structures.

Vesico-colic fistula.—Such a fistula is typically situated on the left side of the fundus of the bladder, and is usually due to diverticulitis. In 136 cases analysed by Lockhart-Mummery, 12 had perforation into the bladder and developed vesico-colic fistula.† Occasionally it results from a malignant growth of the bowel. Cancer of the bladder rarely gives rise to fistulæ, as death supervenes before this complication develops. In 328 cases of vesico-intestinal fistula collected by Higgens‡ diverticulitis was the cause in 92, and cancer of the bowel in 49. The remaining cases were due to trauma, other inflammatory conditions, tumours of other organs, and congenital anomalies.

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* "Traité de Chirurgie d'Urologie," 2nd Edn., ii, 1623.
† "Late Results in Diverticulitis," *Lancet*, 1938, ii, 1401.
‡ *Journ. Urol.*, 1936, xxxvi, 694.

The first step in treatment is the establishment of a colostomy proximal to the vesico-colic fistula. The pelvic colon should be used for this purpose, if not affected by diverticulitis. If, however, an inguinal colostomy is not practicable, the transverse colon must be employed. In rare instances this portion of the bowel may itself be the site of fistulous communication with the bladder, and if so, a cæcostomy is necessary. An exploratory laparotomy at this stage should be avoided on account of the massive induration in the pelvis, unless it is necessary to determine which portion of the bowel is suited for purposes of colostomy.

Within two or three weeks after this operation the bladder symptoms usually disappear, owing to healing of the vesical orifice of the fistula, and are unlikely to recur in cases of diverticulitis if the lower bowel has been completely excluded. Cystostomy also may be required when the fistula is due to malignant disease because, although colostomy will considerably relieve the symptoms, the ulceration in the bladder will not heal. Resection of the affected bowel and fistula should only be undertaken for recurrence of symptoms, and in diverticulitis eighteen months should elapse between colostomy and such operations.*

Recto-vesical fistula used to be common after the operation of lateral lithotomy. It may result from wounds, and occasionally when the prostate has been improperly treated by perurethral resection, or as a result of radium burns. If due to radium, permanent colostomy will be necessary. In the other conditions the bladder should be drained by an indwelling catheter with the patient lying prone. If this fails the fistulæ may heal after cystostomy. If further operation is required it is best undertaken through the perineum, the bladder being separated from the rectum as in perineal prostatectomy. This may be very difficult on account of adhesions. Each organ is then stitched separately.

A transvesical approach has also been employed, the procedure being similar to that used in the operative treatment of vesico-vaginal fistula.

The fistula may also be approached through the rectum, though this is the least satisfactory route. After the sphincter has been cut, the orifice of the fistula is exposed. By dissection around it the bowel is detached from the bladder, and the openings in both structures are closed.

OPERATIONS FOR INCONTINENCE OF URINE

Incontinence of urine may be due to (1) congenital abnormalities such as ectopia (*see* p. 1991), epispadias, which in the female may easily be overlooked, or an accessory ureter opening into the vagina; (2) impairment of sphincter control; (3) destruction of the urethra in the female; (4) vesico-vaginal fistula (p. 2030); (5) uretero-vaginal fistula; (6) severe degrees of contracture of the bladder; and (7) overflow from a distended bladder.

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* Nitch, C. A. R., and Lett, H., "Urinary Complications of Diseases of the Large Intestine," Joint Discussion, Section of Surgery and Section of Urology, May, 1932, *Proc. Roy. Soc. Med.*, 1932, xxv, 1802.

Impairment of sphincter control must be discussed separately for the male and female.

Incontinence of urine due to sphincter impairment in the male. —The urine is normally held by both the internal and the external vesical sphincters. Either is adequate to control micturition. In Wheelhouse's operation the external sphincter may have to be divided, but the patient has control of micturition unless the function of the internal sphincter is also impaired as a result of prostatic abscess or a previous prostatectomy. The latter operation should, therefore, be avoided in a patient who has undergone external urethrotomy and *vice versa*. It is, however, uncommon for prostatic enlargement to develop when there is a severe degree of urethral stricture of long standing.

It was at one time considered that, after Young's method of perineal prostatectomy, the urine was controlled by the internal sphincter. This is incorrect, for control depends upon the efficiency of the external sphincter after this operation, just as after suprapubic prostatectomy. Young has described an operation for incontinence of urine following perineal prostatectomy, but the condition should not occur if the technique described on p. 2074 is employed.

Young's operation for sphincter repair after perineal prostatectomy.— —The bladder is opened through a suprapubic incision and the trigone fully exposed. The trigonal mucosa is incised and removed, denuding the internal sphincter, which is brought tightly together from side to side by chromic catgut sutures. The bladder-wound is closed, a tube draining its upper angle. The patient is now put in the lithotomy position and a rubber catheter is introduced through the urethra. An oval perineal incision is made, including the scar tissue down to the triangular ligament, and the urethra is identified, aided by the rubber catheter *in situ*. If the posterior urethra is dilated, a portion of its wall is excised and the two edges are sutured with chromic catgut. The muscle tissue of the external sphincter is sought on each side and approximated over the urethra, a second or possibly a third line of sutures being required for that purpose. A soft catheter is retained in the urethra for 8–10 days.

The function of the external sphincter is sometimes interfered with *after suprapubic prostatectomy*. Before deciding on treatment the urethra should be explored with a posterior urethroscope and bougies. If any contracture is present this should be treated by dilatation, for the consequent absorption of scar-tissue will usually allow the external sphincter to resume its full control.

Exercises and massage to improve the tone of the buttock muscles and of the adductors of the thighs are useful where the external sphincter, though not damaged in structure, requires re-education.

In the rare instances in which such measures fail, Young's operation may be employed to avoid wearing a urinal. Another alternative, is permanent supra-pubic drainage after the bladder outlet has been exposed through a cystostomy incision and closed by sutures. Transplantation of the ureters into the colon may be the solution (*see* p. 1966).

Incontinence of urine due to sphincter impairment in the female.— —This condition is most commonly due to childbirth, which has led to weakness of the pelvic floor and formation of cystocele. It may also occur without cystocele, being due to weakness of the supports of the bladder-neck and urethra. When the patient coughs a jet of urine is seen to escape from the external meatus, but the anterior vaginal wall does not descend as much as when a cystocele is present.

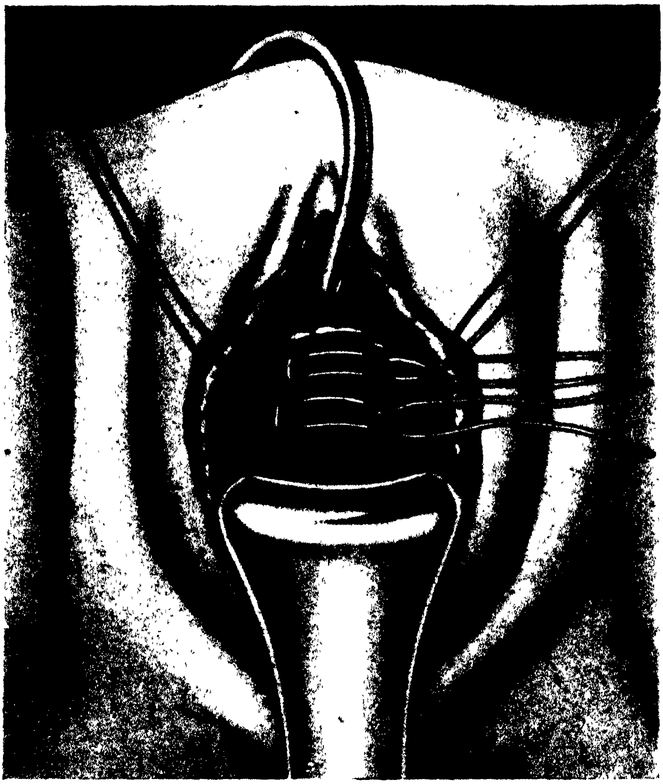

Fig. 994.—Marion's repair of the vesical neck. A de Pezzer catheter is in position and sutures of thread have been inserted through the fibro-muscular tissues.

From " Traité d'Urologie."

Marion's operation on the female urethra for restoration of function.— —A de Pezzer catheter size 22 French (12 English) is passed along the urethra into the bladder with the aid of a stylet, and is then gently pulled upon to bring its mushroom end into apposition with the internal urinary meatus. The anterior vaginal wall is then incised transversely immediately behind the opening of the external urinary meatus for about 4 cm. The vaginal mucosa is separated by dissection with scissors, and stripped from the urethra and the vesical neck for a distance of about 5 cm. When this has been done, the exact position of the internal meatus and the neck of the bladder is easily recognized by feeling for the head of the de Pezzer catheter through the bladder-wall. Immediately in front of this a mattress-suture of thread is passed, picking up all the muscular layers of the bladder-wall on each side of the middle line, and others are then placed between this and the opening of the urethra (Fig. 994). When these are tied they bring together beneath the vesical neck and the urethra the muscular and fibrous tissues situated on either side of it. This line of sutures is supported by others picking up the ischio-clitoris muscles on either side as in an anterior colporrhaphy (Fig. 995). When these have been

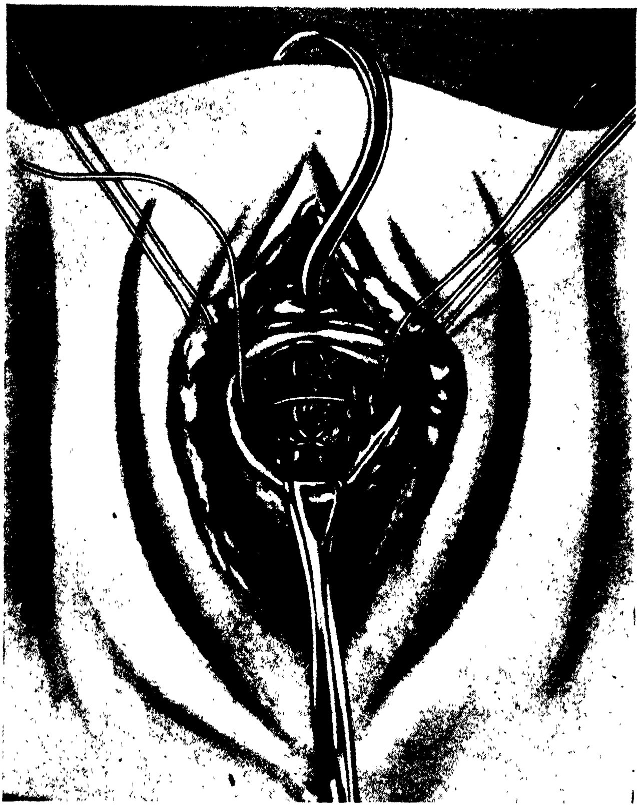

Fig. 995.—First sutures tied. A second layer picks up the ischio-clitoral muscles. The vaginal wall is then closed with a third layer.

From " Traité d'Urologie."

tied, the incision in the vaginal wall is sutured transversely. The de Pezzer catheter is removed on the 12th day. There may be difficulty in micturition for some days. This should be treated by catheterization until normal micturition is established. The results of this operation are very satisfactory.

Destruction of the urethra in the female.—When incontinence of urine is the result of severe damage to the bladder-base and takes the form of a vesico-vaginal fistula which includes the urethra, extensive treatment is necessary. The ureters may be transplanted into the colon (*see* p. 1966), or operative procedures described by Marion * may be employed.

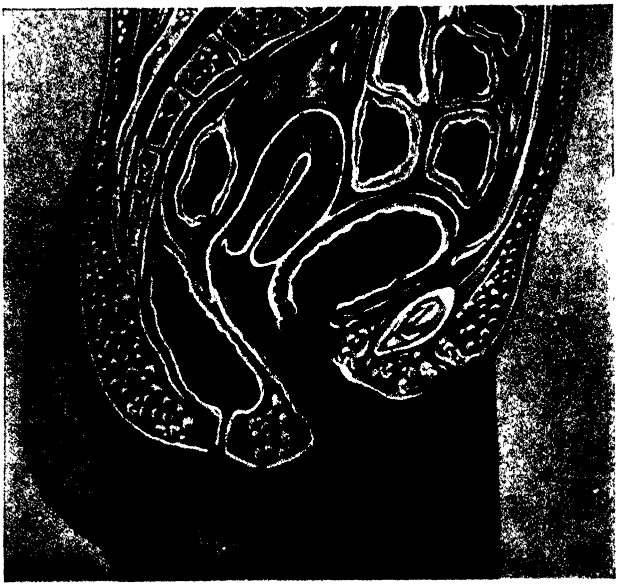

Fig. 996.—Marion's reconstruction of the female urethra. The dotted lines indicate the plane in which the bladder is freed from the surrounding tissue.

From " Traité d'Urologie."

Reconstruction of the urethra in the female.—At the first operation suprapubic cystostomy is performed, a de Pezzer tube providing drainage. The patient is then placed in the lithotomy position and a dissection is carried out to free the vagina from the bladder and urethra (Fig. 996). The latter structures are now completely closed by two layers of sutures infolding the raw edges upwards into the bladder (Fig. 997). The free edge of the anterior vaginal wall is attached by sutures to the tissues immediately beneath the symphysis pubis, and completely shuts off the bladder (Fig. 998). The vagina

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* " Traité d'Urologie," 3rd Edn., ii, 1139.

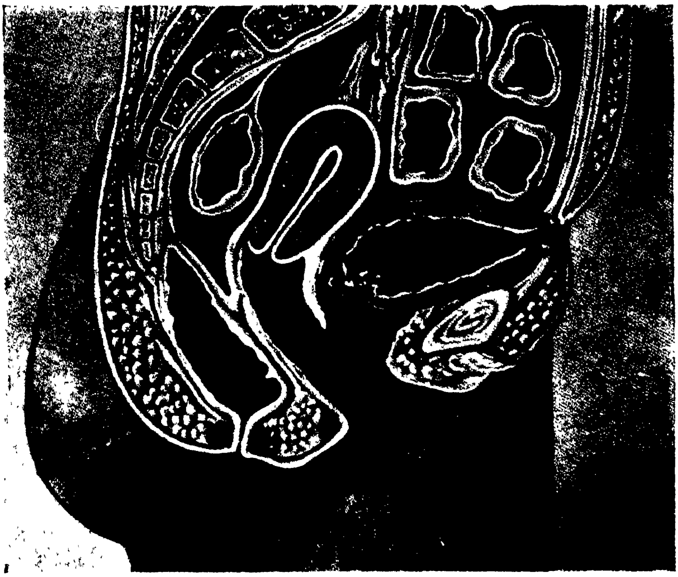
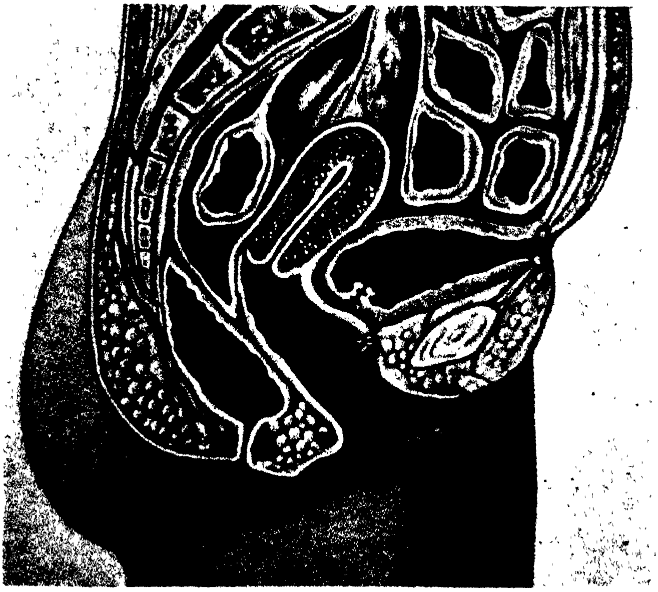


Fig. 997.—Closure of the fistula by inversion of the bladder walls.

From " Traité d'Urologie."



of vaginal wall is sutured to the raw surface below
[illegible]

From " Traité d'Urologie."

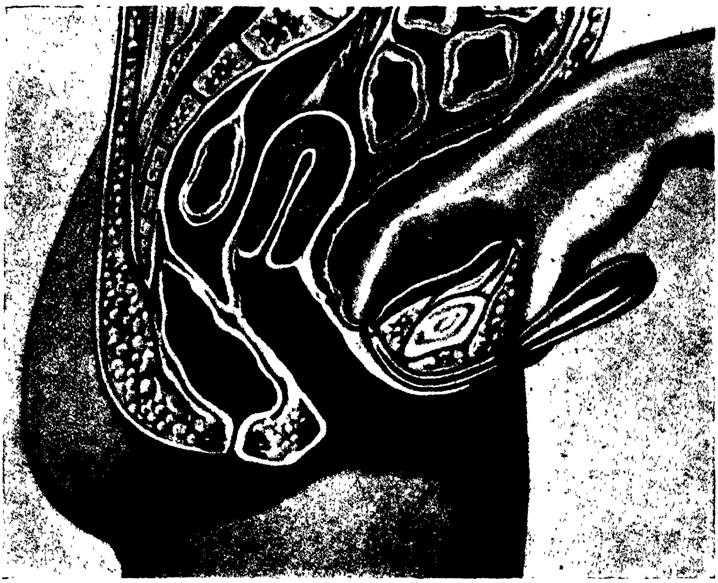


Fig. 999.—A tunnel is made with a curved trocar.
From "Traité d'Urologie."

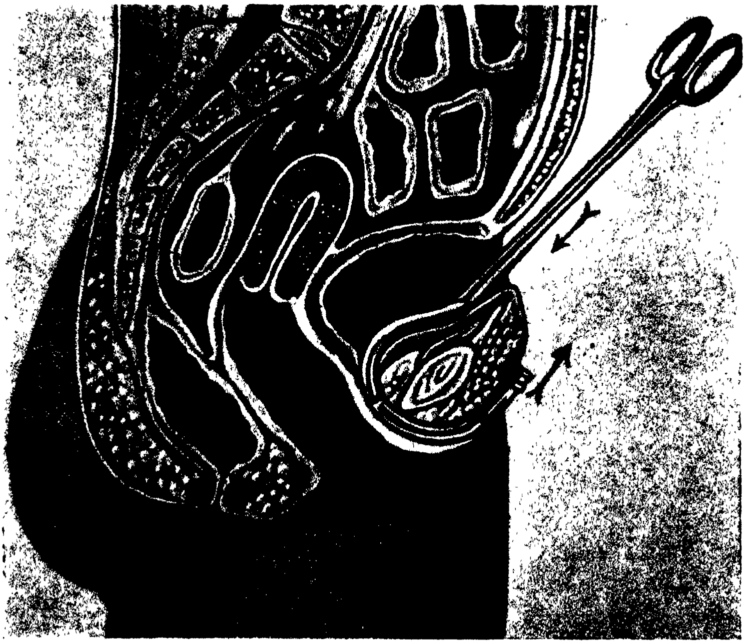


Fig. 1000.—A curved clamp is passed through the tunnel and into the cannula.
From "Traité d'Urologie."

is packed with gauze. By this means the normal outlet of the bladder is permanently obliterated.

Six months later a second operation is undertaken to establish an artificial urethra. A graft 7 cm. by 3 cm. is cut from the posterior vaginal wall. This is formed into a tube with the epidermal surface inwards, and is sutured with fine catgut at intervals around a small bougie that has been specially cut short so that it is only slightly longer than the length of the graft. A special curved trocar and cannula is thrust upwards, through the soft tissues in the middle line, immediately below the clitoris, between the pubic bones and the anterior vaginal wall, to enter the bladder, where its point is located by a finger passed through the suprapubic fistula (Fig. 999). The trocar is withdrawn from the cannula and a special curved forceps is passed through the suprapubic wound so that the tips enter the orifice of the cannula at the floor of the bladder (Fig. 1000). The latter is then slowly withdrawn, the points of the forceps following it through the track beneath the pubic arch to appear in the region of the clitoris anteriorly. The forceps is opened sufficiently to grasp the end of the tubular graft, which is ready rolled round the short bougie (Fig. 1001). The forceps is slowly withdrawn from the bladder

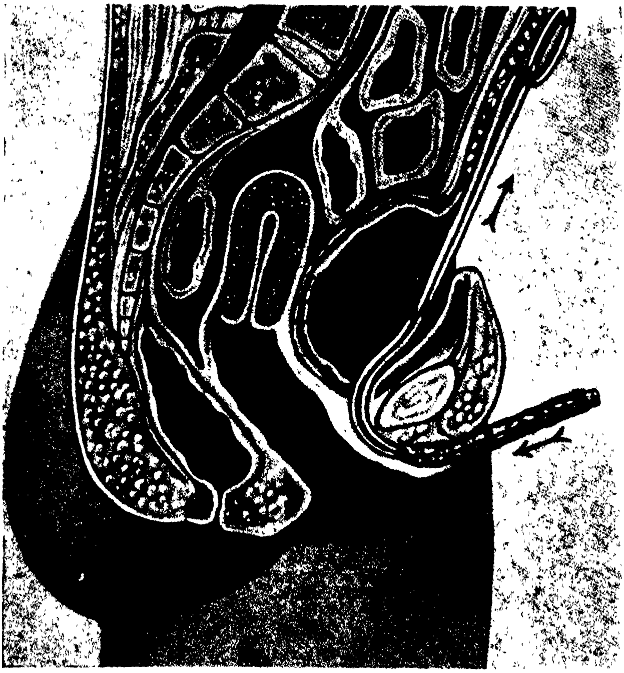


Fig. 1001.—The cannula has been withdrawn. The jaws of the clamp are opened to dilate the tunnel and to grip the graft.

From "Traité d'Urologie."

and pulls the graft with it along the infrapubic tract (Fig. 1002). At the same time the bougie is pushed along the canal so that the graft does not slip off. When the end of the graft has been drawn so that it lies just within the bladder cavity, the forceps relaxes its grasp and is removed. The bougie is left in position as an internal splint and the graft is not fixed by sutures. The de Pezzer tube is replaced in the suprapubic wound.

About the 15th day the short bougie is withdrawn, as by this time the graft has become established as a lining to the artificial urethra. It is replaced by a catheter, the de Pezzer tube being removed from the suprapubic wound, which is allowed to close. The patient is provided with a suitable sound which she is taught to introduce from time to time to maintain dilatation of the canal. Marion finds that this operation provides the patient with voluntary micturition and control.

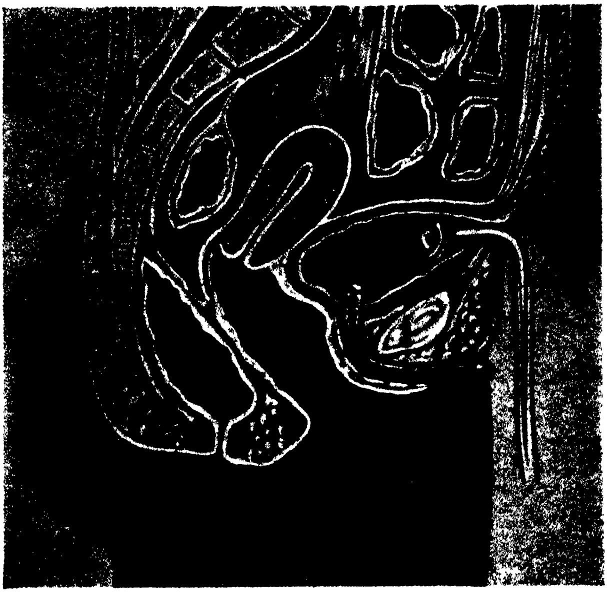


Fig. 1002.—The graft has been drawn into position, together with the piece of catheter which forms the internal splint.

From "Traité d'Urologie."

Incontinence of urine due to severe degrees of contracture of the bladder.—Intense frequency of micturition results from contracted bladder, but this may be so severe that it amounts to incontinence of urine, which indeed becomes complete in the advanced stages of the disease. It usually results from cystitis of long standing, most often due to the tubercle bacillus, but occasionally to other organisms. Sometimes it occurs apart from bacterial infection. Presacral neurectomy has occasionally proved successful. Transplantation of the ureters into the colon may be undertaken, provided the patient has not become a drug addict, as is not infrequently the case.

When incontinence of urine develops in spina bifida no urological operative treatment is possible. Transplantation of the ureters into the colon must not be undertaken without careful consideration, as sphincter control of the rectum may be imperfect.*

Overflow from a distended bladder.—This may be due to obstruction arising in any part of the urethra—for example, in children, to pinhole meatus, congenital valvular obstruction, or congenital stricture; or in adults, to stricture. The treatment of these conditions is described on p. 2109. Other causes are prostatic obstruction (p. 2050), post-prostatectomy obstruction (p. 2099), and diseases of the central nervous system. Of the last-mentioned the commonest are tabes dorsalis, disseminated sclerosis, spina bifida, and injuries to the spinal cord.

In tabes dorsalis operation will only be undertaken if there is serious impairment of renal function, and this does not usually occur unless the amount of residual urine is very large. The correct operation is permanent cystostomy. Catheterization is to be avoided, if possible, on account of the risk of infection. Prostatic enlargement may be associated with tabes dorsalis, and, if prostatectomy is performed, there is a risk, which is difficult to assess, that micturition may not be re-established. Perurethral resection carries less risk.

In disseminated sclerosis large amounts of residual urine are also tolerated, even when infected, and as any operative procedure unfavourably affects the general course of the disease, it is to be avoided if possible. Cystostomy, however, may become necessary.

Injury to the spinal cord sometimes causes an " automatic bladder."† In many instances, however, permanent cystostomy will be necessary (p. 1988). In spina bifida, transplantation of the ureters into the bowel should not be undertaken as the function of the rectal sphincter is rarely normal. Permanent cystostomy may be required in rare instances, because of persistent leakage, or to relieve impaired renal function, but in most cases operation is best avoided.

OPERATION FOR PERSISTENT SUPRAPUBIC FISTULA

The fistula which results from a suprapubic operation on the bladder commonly closes spontaneously, provided there is no obstruction at the vesical outlet. Should closure be delayed, it can usually be obtained by tying in a catheter (*see* p. 1988), provided this is correctly adjusted and allowed to drain continuously. If the sinus is of long standing, closure may sometimes be expedited, when drainage has thus been provided, by scraping its walls down to the level of the vesical mucosa with a sharp-edged spoon, or by cauterizing with a silver-nitrate stick. If such measures fail, before proceeding to secondary suture of the wound, the case should be reviewed to ensure that obstruction at the vesical outlet has not escaped notice. Very minor degrees of prostatic enlargement will cause a sinus to persist. The condition is best recognized by the panendoscope through which treatment may sometimes be undertaken (*see* p. 2081). Perurethral resection of the prostate may be required (*see* p. 2082). Stenosis of the col vesicæ is another condition which may be overlooked (*see* p. 2028). The patient should also be examined for disease of the central nervous system, which may have been missed in the pre-operative investigation.

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* E. M. Corner, *Ann. Surg.*, 1901, xxxiv, 457.

† Thomson-Walker, " The Treatment of the Bladder in spinal injuries in war," *Brit. Journ. Urol.*, Sept. 1937, ix, 217.

In a small proportion of cases in which none of these conditions exist, catheter drainage proves unsuccessful, and therefore secondary suture becomes necessary. The fistula should be completely excised as described on p. 1982, and the bladder mobilized; this will include freeing it from the back of the symphysis pubis if it is adherent. The operation is completed in the manner described for immediate suture after cystotomy (*see* p. 1983).

OPERATION FOR INTRACTABLE VESICAL PAIN

Presacral neurectomy (*see* p. 1814) sometimes gives relief, though in a high proportion of cases this has been only temporary. In the majority of instances no benefit has been achieved. A disadvantage of this method in the male is that sterility, though not impotence results, because the seminal vesicles become paralysed and ejaculation does not occur.

Chordotomy.—A division of the antero-lateral tracts of the spinal cord (p. 402) provides certain relief for pain having origin in the bladder or the prostate. The operation is unlikely to be advised until pain is severe, and by this time addiction to drugs has frequently become established, a habit which the patient is unwilling to forego even when the painful sensations have been abolished. For this reason the operation is only rarely employed.

Injection of alcohol into the spinal theca.—By this treatment (*see* p. 393), if it is successfully carried out, the posterior primary divisions of the appropriate nerves can be rendered functionless, and the relief of pain is thereby obtained. Previously established drug-addiction is likely to spoil the results.

Riches' method of suprapubic catheterization* is also useful. A very small skin incision is made at the highest point of bladder dullness, or at the midpoint between the umbilicus and symphysis, whichever is the lower. A local anæsthetic may be used. A special introducer, with the catheter stretched on it and well lubricated, is passed in a downward and backward direction, making an angle of 45° with the abdominal wall. When the knife-point has been felt to enter the bladder and has passed two inches further, the stretched catheter is released and the knife-point is sheathed. By means of an introducer, the catheter is then advanced to a suitable distance. The position of the catheter is maintained by a rubber shield which is strapped to the abdomen.

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* Riches *Lancet*, July 31, 1943, ii, 128

CHAPTER XLIII

OPERATIONS ON THE PROSTATE

By R. OGIER WARD

Anatomical and physiological considerations.—When the prostate gland is the seat of changes known as benign, simple, or ' adenomatous ' enlargement, the portion so affected is that which lies above the common ejaculatory ducts. This can be enucleated from within a false or pathological capsule which is formed from the flattened-out residue of the gland, and is itself enclosed within the anatomical prostatic capsule derived from the fasciæ which cover the neighbouring structures. The enlargement may be chiefly subvesical, but commonly there is also an intravesical projection, and this, as it develops, stretches the internal vesical sphincter and pushes up the bladder mucosa around the internal urinary meatus, transforming the latter into a cleft, opening into the bladder above and anteriorly. In suprapubic prostatectomy the finger is commonly introduced into this cleft to rupture the mucous membrane and to find the plane of cleavage between the enlargement and the false capsule. The tumour is shelled out of this, the prostatic urethra being torn across obliquely, just above the level of the verumontanum posteriorly, down to the membranous urethra anteriorly. That part of the gland which lies below the common ejaculatory ducts is left in position.

In perineal prostatectomy the dissection exposes the posterior and inferior aspects of the gland contained within its fascial covering. This true capsule and the false capsule within it are incised to open up the plane of cleavage between the latter and the tumour, which is then enucleated from inside it, the intravesical projection being freed from the surrounding internal sphincter and from beneath the trigone. The common ejaculatory ducts are usually cut across unless separate incisions are made for the removal of each lateral lobe, or unless the gland is approached from the point where the membranous urethra joins it.

The shape of the cavity left after enucleation of the prostate by either of these methods depends upon the form of the tumour which has been removed. The opening into the bladder is usually much smaller than the space below, and though the internal sphincter is forcibly stretched during the operation this muscle usually contracts the opening to a small size within a few minutes, so that the cavity becomes roofed over posteriorly by it and by the muscles and mucosa of the trigone. The seminal vesicles lie immediately below and behind this shelf of tissue, and are not detached during enucleation unless the false capsule is ill-defined in that region, or is accidentally torn through.

At the outlet from the bladder into the prostatic fossa the torn edge of the mucosa is seen all round its circumference. The wall of the cavity below may be quite smooth and glistening white when not covered with blood, or there may be attached to it shreds or tags derived from the false capsule, and flattened or rounded nodules of ‘ adenomatous ’ tissue.

Hæmorrhage after the operation comes in part from arteries and veins at the vesical neck in the edge of the mucous membrane, and just beneath this at the level of the internal sphincter ; in part also from arteries in the lateral walls of the cavity, and from veins of the prostatic plexus opening into it.

The weight of the enucleated prostate varies from 2 drachms to several ounces. The weight of 1,550 prostates removed by Freyer [*] varied from ½ oz. to 17 oz. (14–482 gm.). Thomson-Walker[†] removed a prostate weighing 24 oz. (680 gm.) from a man aged 76.

In perurethral prostatectomy portions of the enlargement are cut away, usually including the whole of the intravesical projection and parts of the lateral lobes. After prostatectomy the internal sphincter does not resume its function, but the compressor urethræ or external sphincter controls the outflow of urine. The prostatic cavity gradually shrinks until it is little larger than the normal prostatic urethra. Contraction at the bladder outlet may lead to serious narrowing or complete obliteration of the opening. Less often, a stricture may form at the junction of the cavity with the membranous urethra.

Sexual function.—The patient is almost invariably sterile after suprapubic prostatectomy, owing to the fact that the internal sphincter of the bladder is no longer competent. During the sexual orgasm the semen, as it is discharged into the posterior urethra, flows up into the bladder and is passed at the next micturition. While patients who have undergone suprapubic prostatectomy are sterile, in only a limited number of cases are they impotent.

Anæsthesia in prostatic operations.—The average age of the patient who requires operation for prostatic obstruction is over 60 years. A considerable proportion have cardio-vascular disease, such as arteriosclerosis with hyperpiesis or myocardial degeneration. Many have pulmonary complications with some emphysema and bronchitis. Some impairment of renal function and sepsis of the urinary tract are not infrequently present. The average patient is, therefore, not a particularly good risk.

It is of interest to analyse the forms of anæsthesia which may be employed. In a series of 200 consecutive prostatectomies performed at St. Peter's Hospital during the period 1936–37, the following methods were used :

	No. of Cases	
Open ether	115	(57.5 per cent.)
Nitrous oxide and oxygen with avertin	36	(18 „ „)
Spinal	33	(16.5 „ „)
Nitrous oxide, oxygen and ether .	16	(8 „ „)
Cyclopropane	10	(5 „ „)

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[*] *Brit. Med. Journ.*, 1919, i, 121.

[†] *Brit. Journ. Surg.*, 1920, vii, 526.

All cases received pre-operative medication. The majority were given atropine, and a considerable number scopolamine and morphia, or omnopon. It is, however, important that premedication should not be such as will prolong the unconscious state for a lengthy period, since this limits the early institution of diuresis. This may be of the utmost importance, either in the treatment of uræmia or the maintenance of adequate flushing when drainage is provided by a urethral catheter. Certain of the cyclopropane cases were induced with evipan and some of the spinal cases were given gas-and-oxygen or chloroform-ether mixture in addition. It is worthy of note that there were extremely few postoperative complications attributable to anæsthesia, and these did not occur with greater frequency after any one method.

When an operation of the Harris type is being performed, it is important to employ an anæsthetic which does not produce a fall in blood-pressure. Otherwise, a false impression may be formed of the adequacy of hæmostasis and there may be a considerable degree of reactionary hæmorrhage. In transurethral resection of the prostate, on the other hand, a temporary lowering of the blood-pressure to some slight degree, and consequent diminution of bleeding in the operation field, increases the ease and quickness of the operation and allows the operator to see and coagulate the bleeding-points. In this method spinal anæsthesia is an advantage. Except for the above considerations, in the large majority of cases, if the anæsthetic is efficiently administered, the method employed appears to be of secondary importance.

BENIGN PROSTATIC OBSTRUCTIONS

Indications for the treatment of prostatic obstruction.—**The presence of residual urine** is by far the most important, for the reason that if the volume is large and constant the kidneys become impaired in function and eventually renal failure results. When there is evidence of this, either from clinical or laboratory examinations, treatment must be undertaken. In the absence of such renal signs, surgical opinion differs on the volume of residual urine which calls for treatment. Some consider that the patient is best left alone unless the amount reaches 10 oz. ; others advise treatment for much smaller quantities. In the opinion of most, however, if there is a consistent residuum of 5 oz. treatment should be undertaken, particularly if the volume has shown an increase over a period of months or years. The patient's age must also be considered. Much larger volumes of residual urine may go untreated when the patient is of advanced years, or when the expectation of life for other reasons is relatively short. The effects of obstruction to the outflow of urine from the bladder must be considered apart from the actual volume of residual urine, and the effect upon the kidneys, for in some cases, although this is small, the bladder may be observed on cystoscopy to show marked signs of stress, multiple sacculation and trabeculation being present. These signs constitute a clear indication for the treatment of the obstruction, even though the amount of residual urine may be only one or two ounces.

When urinary infection occurs in a case of prostatic enlargement the amount of residual urine is greatly reduced; indeed, it may disappear altogether during the most acute period of cystitis. It re-appears gradually as the condition subsides, and when the infection becomes chronic the volume further increases, but usually remains considerably less than that present before the onset of cystitis. It follows, therefore, that the volumes mentioned in the preceding paragraph, which refer to cases with sterile urine, are excessive for cystitis.

2. Attacks of **retention of urine** recurring with increasing frequency are an indication for treatment, even when in the intervals residual urine is small in amount, or entirely absent.

3. **Frequent micturition** is not of itself an indication for treatment, unless residual urine be also present, which is by no means always the case. However, it must be considered if it produces great inconvenience, and particularly when slowness of micturition causes the patient to spend a long time out of bed, and thereby seriously interferes with sleep.

4. **Hæmorrhage** from the enlarged prostate when recurrent, or rarely on a single occasion, may necessitate operation, particularly if sufficient to cause clots to collect in the bladder.

5. **Cystitis** associated with residual urine, which does not respond to non-operative treatment, requires operation. Special consideration must be given if pyelitis or pyelo-nephritis is also present.

6. **Recurrent stone formation.**

When these conditions are present, whatever may be the changes in the prostate which have brought them about, treatment of the obstruction is indicated. The choice of method will vary in different cases, and according to the technique favoured by the surgeon.

Treatment by Hormones

The ætiology of simple enlargement of the prostate is uncertain, but there is evidence that the hypertrophy of the middle lobe arises from the sub-cervical gland or from both, and that the lateral-lobe hypertrophy is due to changes originating in the prostate itself. It seems unlikely, however, that these changes are a simple hyperplasia of the normal gland. There are several theories designed to demonstrate that prostatic enlargement is controlled by an internal secretion of the testes, perhaps balanced by a secretion of the pituitary gland. Castration has been performed in the treatment of benign enlargement of the prostate, and in certain cases it seems clear that an undoubted diminution in size resulted, but the operation is not nowadays employed. At the present time much research is being undertaken with a view to determining the nature of the hormones, the existence of which is presupposed, and to synthesizing substances which can be used for treatment. Several of these are under trial, but it is yet too early to decide their value.

TREATMENT BY LIGATURE OF THE DUCTS OF THE TESTICLE

Steinach proposed bilateral vaso-ligation to produce rejuvenation. He subsequently claimed that, by enhancing the internal secretion of the testes, enlargement of the prostate could be successfully treated. Later, he declared that better results were obtained if a ligature was placed around the vasa efferentia between the globus major and each testis, and this operation has been extensively practised by some surgeons. It is stated that, in addition to causing a gradual shrinkage in the size of the gland and a permanent relief of symptoms, the measure in many cases is sufficient to relieve retention of urine. While it seems clear that beneficial results are obtained in some cases, it is certain that the value of the operation has been grossly exaggerated.*

THE PREVENTION OF EPIDIDYMITIS

Vasotomy is a certain means of avoiding attacks of epididymitis, which often constitute a serious disturbance during convalescence after prostatectomy. This procedure does not prevent the development of acute seminal vesiculitis, which will still occur in a certain proportion of cases but tends to resolve spontaneously. Occasionally a small abscess, which will yield to fomentations, may appear at the site of the vasotomy in the scrotum. Neither of these conditions is so disabling or painful as acute epididymitis. Vasotomy is usually performed immediately before the main operation but can be undertaken at any stage. If desired it can be carried out under local anæsthesia before instituting any other treatment.

Technique.—After shaving, the lower part of the abdomen, the penis, scrotum and inner side of the thighs are well cleaned with spirit, and the scrotum is held up while a mackintosh sheet is placed across the thighs and beneath it. Beginning on one side, the spermatic cord is pressed between the first two fingers and thumb of the left hand until the vas deferens is separated from the other constituents and made to lie immediately beneath the skin. An incision is made over it for ⅜ in. and carried down through the various layers until the vas is reached. Throughout this dissection it is essential not to relax the grip of the left hand. The vas is then picked up with strong toothed dissecting-forceps, drawn out of the wound and dissected from the other structures of the cord for about ½ in. Two strong pressure forceps are applied to it and it is divided between them, each end being ligatured separately. The skin-incision is then closed with two interrupted sutures of fine plain catgut. The other side is then similarly treated. If the vas deferens is not promptly found, or if during dissection it is temporarily lost, it is best to deliver the whole cord for about 1½ in. from the scrotum in order to secure the duct.

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* "The Treatment of Prostatic Obstruction other than by Prostatectomy," H. Lett, *Brit. Journ. Surg.*, July, 1937, xxv, 191.

PROSTATECTOMY

Information required before performing prostatectomy.—Full information must be obtained of the condition of the pulmonary, circulatory, gastro-intestinal, and nervous systems.

Prostate.—The prostate should be examined by rectal and bimanual palpation for evidence of malignancy, such as leathery areas in an elastic prostate, hard irregular nodules, fixation of the gland, or thickening and nodules along the lymphatic path on either side and above the prostate. Cystoscopy may show an intravesical projection of the prostate where palpation fails to detect enlargement. When the prostate is large, cystoscopy may be dangerous, and if considered necessary should be done when the patient is anæsthetized, immediately before the operation.

Bladder.—The amount of residual urine should be ascertained by catheter, unless chronic distension of the bladder is evident on suprapubic palpation. If the prostatectomy is to be carried out through a limited incision which will not permit the introduction of retractors for inspection of the bladder, a previous cystoscopy is essential. The condition of the bladder-wall will thus be ascertained. Sacculation and trabeculation in marked degree indicate failure of the bladder-muscle to compensate for the prostatic obstruction. Any diverticulum will be discovered and its presence will affect the nature of the operation. Neoplasms or calculi will be seen.

Kidneys.—The state of the renal function must be known. It is ascertained by history, clinical examination and laboratory tests ; the blood urea is the most important. The urine must be fully examined, and frequently inspected both before and after operation. The blood group should be determined before operation.

PRELIMINARY TREATMENT

This is directed primarily to the urinary system, but also to the gastro-intestinal, circulatory, respiratory, and nervous systems. If glycosuria is present, this should be investigated and controlled. The preliminary treatment of the urinary system comprises the treatment of renal insufficiency and of urinary infection.

The treatment of **renal insufficiency** consists in the removal of the retained urine and stimulation of the kidney-secretion. The patient is kept in bed, the bowels freely opened, and the bladder emptied and drained continuously. This may be effected by catheterization.

If **acute retention** of urine is present and if there is no evidence that it is superimposed upon obstruction of long standing which has brought about renal insufficiency, the bladder may be completely emptied by catheter. This is also permissible when **urinary sepsis** particularly calls for treatment, and the amount of residual urine is not large. If **chronic retention** of urine is accompanied by renal insufficiency, the bladder must be emptied carefully, either by intermittent catheterization three times in the twenty-four hours, withdrawing half or three-quarters of a pint on each occasion until the bladder is emptied, or by tying in a catheter and removing the plug from it at intervals.* When drainage has thus been provided, the patient is encouraged to drink large volumes of water, weak tea and barley water to promote diuresis. After about a week it will be possible to decide from clinical examination and the repetition of the tests for renal function whether it is safe to proceed to prostatectomy in one stage.

In mild grades of **urinary infection** it will suffice to carry out regular lavage of the bladder through a catheter, together with the administration of urinary antiseptics, and if the urine is alkaline, sodium acid phosphate and sodium benzoate should be administered. In severe grades of cystitis it will be necessary to provide suprapubic drainage and establish continuous irrigation (*see* p. 1988).

Choice of Method

The various methods of prostatectomy are discussed under their appropriate headings and the special indications for the use of each are described. It seems desirable, however, to point out that no one method can be relied upon to give the best result in all cases. There has been a tendency on the part of those who strongly prefer a particular form to endeavour to prove their method to be so superior that all others are rendered obsolete. But patients who suffer from benign enlargement of the prostate differ widely, both in physical configuration and fitness and in resistance to the shock of operation. Still more variable is the size of the prostate which is the object of treatment. An operation, therefore, which is easily and effectively performed in one case may be extremely difficult in another.

The operation introduced by Freyer, enucleation of the prostate through a small abdominal incision, remains a most valuable procedure, whether it is performed in one or two stages. There is, however, no doubt that, on account of the impossibility of making more than a digital examination of the interior of the bladder, associated conditions, such as vesical diverticulum or neoplasm, have often been overlooked, particularly if preliminary cystoscopy is omitted. An operation carried out through the large abdominal incision of Thomson-Walker obviates this and, if combined with the method of suture originated by Harris, or a modification, produces successful hæmostasis in most cases. In spite of all that is gained by thus limiting the loss of blood, there will always be many patients too frail to survive an operation which is necessarily somewhat prolonged. In such cases radical cure may often be achieved by using Freyer's prostatectomy in two stages, with an adequate interval.

Few surgeons employ perineal prostatectomy as a routine, but it is properly rated as a method of great value, and one which may be specially selected for those patients who, on account of chest complications, would clearly not survive an operation through the abdominal wall.

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* Riches' method is useful for this. See note on p. 2044.

The place of perurethral prostatectomy is not finally decided, but if it is agreed that large prostates are better treated by enucleation, it is equally certain that enucleation should never be used for the small fibrous type which can so successfully be treated by transurethral methods.

These are some of the reasons which make it desirable that the surgeon who treats prostatic obstruction should be sufficiently familiar with the various standard procedures to feel competent to adopt whichever of them seems most suited to a particular case.

SUPRAPUBIC PROSTATECTOMY

The names of Belfield and Fuller in America and McGill in England are inseparably connected with early work on suprapubic prostatectomy, but the operation was not generally practised until Freyer * had shown how successfully it could be performed. He advocated the "complete" removal of the prostate in all cases of enlargement, and published a long series of cases from 1901 onwards.

ONE-STAGE OPERATION

Contra-indications.—1. Chronic retention of urine of more than 10 oz., unless it can be proved that the patient's renal efficiency has not thereby been impaired, and is not adversely affected by preliminary emptying of the bladder by catheter.

2. Signs of failure of renal function. Clinical evidence is always very important. Prostatectomy may be safely undertaken if the blood-urea is below 40 mg., provided there is no other evidence of renal insufficiency.
3. Severe sepsis : acute cystitis, chronic cystitis of severe grade, pyelitis with rigors, pyelonephritis.
4. Circulatory complications or signs of myocardial failure.
5. Pulmonary complications.
6. Gastro-intestinal complications, oral sepsis, flatulent distention of bowel, chronic constipation.

Freyer's operation.—The pubic region and scrotum are shaved and prepared for operation and the patient is anæsthetized. A catheter is passed and the bladder distended with 8 oz. or more of weak antiseptic lotion or sterile water. The surgeon stands on the patient's left and the assistant on the opposite side. An incision is made in the abdominal wall and then into the bladder,† of just sufficient length to allow two fingers of the right hand to enter—usually about two and a half inches long. The left hand, wearing two gloves, the fore-arm being wrapped round with a sterile towel, is passed beneath the towels arranged on the thighs, and the first two fingers enter the rectum. These are used to push the prostate up towards the surface and to steady it during enucleation. In cases in which the enucleation is easy it may be sufficient merely to support the perineum by pressure with the fingers of the left hand through the towels. Meanwhile, with one of the fingers of the right hand, the enucleation is commenced.

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* *Brit. Med. Journ.*, July 20, 1901, ii, 125. † As for cystotomy, *see* p. 1981.

The enucleation.—Freyer began this by tearing through the mucosa overlying the intravesical projection near the middle line posteriorly, and thus entering the plane of cleavage between the adenomatous enlargement and the pathological prostatic capsule. Another method, and one more generally employed, is to pass one finger down into the cleft of the urethra and then, pressing outwards and slightly forwards, to break through the mucosa immediately in front of the anterior margin of the upper part of the lateral lobe and thus lay open the plane of cleavage. This process may be begun either on the right or on the left side. The finger, perhaps aided by the adjoining one, is now carried round in this plane through a complete circle until the plane is laid open around the entire circumference of the intravesical projection and internal urinary meatus. The enucleation is then continued deeper on the anterior aspect, and thus the finger passes through the internal sphincter into the subvesical region.

There are three points of attachment of the enlarged prostate to its surroundings: posteriorly, at the level of the verumontanum where the band of tissues containing the ejaculatory ducts join the urethra; anteriorly, where the anterior commissure is adherent along the middle line; and at the apex, where the prostatic urethra joins the membranous portion. The last two of these attachments are freed by passing the finger deeply in front of the enlargement and on either side of the middle line until the urethra is reached and is torn across. The ejaculatory ducts hold the urethra so that its posterior wall is usually torn across just above the verumontanum. The tear is very oblique, and not until the lobes are detached is this posterior part of the urethra severed. The enucleation is continued by thrusting the finger down behind the enlargement, between it and the tissues covering the seminal vesicles. This process is continued more deeply and around the gland until the prostate is freed from all attachments. It is then manipulated into the bladder-cavity, which is not always easy if the enlargement is chiefly subvesical and if the internal sphincter has not been stretched by considerable intravesical projection. Against the rectal fingers, the walls of the prostatic cavity are now carefully palpated to ensure that no portion of the main mass of the prostate, or any separate adenoma, has been left behind.

A modification of this method of enucleation, described by Bentley Squier, has been more recently advocated by the late Harry Harris in his writings on prostatectomy (*see* p. 2064). The forefinger is introduced deeply into the prostatic urethra and the mucous membrane ruptured where it covers the lowest part of one or other lateral lobe, about the level of the verumontanum and anterior to it. Each lateral lobe is then enucleated from below upwards. If this method is employed injury to the membranous urethra is very unlikely.

The fingers having been withdrawn from the rectum, a nurse removes the towel which has covered the left forearm and strips off the outer glove without contaminating the one worn beneath it. The prostate is drawn out of the bladder, usually with the fingers, but occasionally some extra aid, such as lithotomy-forceps, is necessary. The bladder is washed out with lotion or water at 120° F. to arrest hæmorrhage.* A large tube with a thick wall, having a bore of ¾ in. and two lateral eyes cut in it near the lower end, is introduced so that at least 2 in. of it are in the bladder-cavity. The end of the tube must not, however, be allowed to extend down to and press upon the trigone, which is allowed to contract down into the vesical space. One, or perhaps two, sutures may be necessary to bring the recti together, and the wound is closed with silkworm-gut sutures, one of which transfixes the tube.

After-treatment. *Local.*—The bladder is irrigated twice daily for the first ten days with oxycyanide of mercury 1 : 6,000 by means of a rubber catheter introduced through the tube. If Marion's tube (Fig. 1003) is used this can be done through the side inlet.. About the fourth day the large tube is replaced by a smaller one in which two lateral eyes should also be cut. A convenient way of introducing it is to select a piece of tubing of a size suitable to pass through the larger one, which is drawn out over it. It is then cut short and transfixed by a large safety-pin to prevent slipping into the bladder. The length of this tube, like that of the tube used at operation, will vary with the thickness of the abdominal wall, but is such that 2 in. are within the bladder. Between the 12th and 14th days the tube is removed and the wound allowed to close. Until then the bladder is washed out through the fistula once daily. Janet's method of transurethral vesical irrigation should not be employed ; it predisposes to epididymitis and seminal vesiculitis. During this period of convalescence a Hamilton-Irving, or better, a McDonald, box is usually employed to collect the urine (Figs. 977, 978, p. 1987).

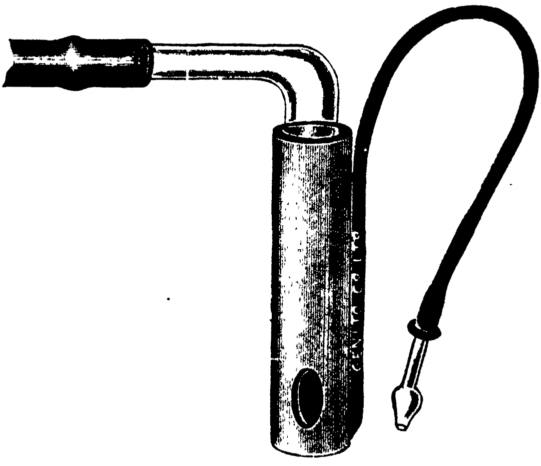

Fig. 1003.—Marion's bladder-drainage tube.

It is advisable, about the tenth day, to pass an instrument through the urethra into the bladder. Sometimes the torn upper end of the urethra becomes closed by adhesions, but at this stage a urethral instrument easily re-opens the way. Many surgeons prefer to pass and tie in a catheter ; a silk web 18 coudé (10 English) is the most suitable. A stylet is sometimes necessary to pass this into the bladder if the trigonal flap and the internal sphincter beneath it overhangs

* Freyer considered this important, but most surgeons omit it.

the prostatic bed. If this method of drainage is employed the patient is kept dry, irrigation is facilitated and the suprapubic wound closes more readily.

General.—Diuresis is of great importance after prostatectomy (*a*) in order to make good the inevitable loss of fluid due to hæmorrhage; (*b*) to maintain the renal function, and (*c*) to act as a continuous bladder-irrigation for the removal of blood-clot and septic accumulations. During the period immediately following operation, nausea and vomiting often prevent the intake of sufficient fluids by the mouth. For this reason about one pint of rectal saline with 5 per cent. glucose should be given on return to bed. If this is carefully and slowly administered the risk of increasing hæmorrhage is slight. It may be repeated at four-hourly intervals for as long as it is retained.

The abundant intake of fluid to which the patient has been trained before operation (*see* p. 2051) must be re-established as soon as possible, and for this purpose small quantities should be given at frequent intervals, in the form of water, barley-water, orangeade, lemonade or weak tea, as the patient fancies. If the intake of fluids by mouth and rectum is still insufficient, *i.e.* a minimum of six pints in twenty-four hours, then continuous intravenous infusion of saline glucose should be instituted, and may be continued indefinitely.

Gastro-intestinal tract.—The effects of a severe operation imposed upon a patient already suffering from some degree of renal impairment, combined with the need to ingest large volumes of fluids, causes a heavy strain upon the alimentary tract. The commonest manifestation of this is flatulence. For its relief a rectal tube may be employed. Injections of pituitrin or pitressin are useful, in doses of ½ c.c. or more, which may be repeated in four hours. The bowels should act within forty-eight hours of operation. Two drachms of cascara evacuant should, therefore, be given on the second night, being supplemented on the following day by an enema if necessary; the risk of this producing hæmorrhage is slight.

The patient should sit up as soon as possible and be instructed in deep breathing. He should also be encouraged to move his lower limbs, with the object of combating venous stasis originating in the pelvic veins, which is a real risk of prostatic surgery. With the same object, a pillow should not be left continuously beneath the knees. Massage of the legs and arms may be started after the first ten days.

It is usually advisable to keep the patient in bed for three weeks to allow firm healing of the abdominal wall.

Difficulties and complications arising during the operation and after-treatment.—Freyer's operation is not easy in obese patients. Fat on the buttocks makes it difficult for the rectal fingers to lift the prostate upwards, and the thickness of the abdominal wall prevents easy access to it from above. Small and adherent prostates, in which the plane of cleavage is imperfectly developed, are often difficult to enucleate, especially if there are adhesions in the region of the seminal vesicles. In all cases it is desirable for the enucleating fingers to keep as close to the gland as possible. If this is not done, the natural plane of cleavage is lost and the tissues surrounding the seminal vesicles are opened up so that these also become in part or in whole detached, and it is necessary to cut through them with scissors. This mistake not only makes enucleation more difficult, but also increases hæmorrhage. Further, it encourages the formation of sepsis by opening up unnecessarily large areas and leaving partially detached tags of tissue. Very large prostates, though easy to enucleate on account of the well-defined plane of cleavage which is always present, are sometimes not easily got out of the bladder, and it may be necessary to deliver each lobe separately on to the surface. These difficulties are partly overcome if a larger abdominal incision is employed. If serious difficulties are encountered during the enucleation, the surgeon should not hesitate to remove the glove from the right hand, as the process is much easier with bare fingers. Tags of prostatic capsule which have become partially detached must be removed. This can usually be done with the fingers, or they can be twisted off with sponge-holding forceps, though this is not easy through the small incision of Freyer.

The urethra is usually torn across without difficulty just above the level of the verumontanum. Every endeavour should be made to effect this. Occasionally, when the prostate is removed the whole of the prostatic urethra and a large part of the mucosa of the membranous portion are found to have been removed also. In these cases it is particularly important not to omit the passage of an instrument about the tenth day, and a watch should be kept for the possible subsequent formation of a stricture.

Primary hæmorrhage.—The imperfect control of hæmorrhage is the great disadvantage of this operation, and irrigation often fails to check it. The surgeon should not be in too much of a hurry to close the wound. It is better to watch the case for a few minutes and, if the hæmorrhage does not diminish, to pack the cavity with a roll of gauze. Two fingers are again introduced into the rectum and with the other hand the end of a roll of gauze, 3 inches wide and several layers thick, is pushed down into the depths of the prostatic cavity, after clots have been taken out, until the space is tightly filled. Some surgeons continue the packing to fill the bladder cavity as a means of keeping the first part in position. The large suprapubic tube is then replaced. The removal of the packing is begun in 48 hours, and completed 24 hours later. Though this is a valuable means of dealing with hæmorrhage, it has the disadvantage that sepsis is encouraged by it, particularly if the bladder was previously infected.* If a hæmostatic bag is available it is more effective. Its use is described on p. 2058.

Hæmorrhage may persist after the patient has left the table, or develop as *reactionary hæmorrhage.* The first essential is to remove clots from the tube with long dissecting-forceps, and to institute continuous irrigation, warm lotion being run from an irrigator through a tied-in catheter and out through a suprapubic box. A solution of

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* It is sometimes a source of painful bladder spasms.

1 : 10,000 silver nitrate is often used for this purpose. In every case a careful watch should be kept upon the patient's general condition, and the pulse counted every half hour. The foot of the bed should be raised on blocks, and morphia, gr. ¼, administered. If the bleeding does not abate, the case should be taken back to the theatre promptly and the prostatic cavity packed. To effect this it is necessary to re-open the wound and remove the tube. If the bladder contains clots these must be evacuated. Blood transfusion may be necessary.

Secondary hæmorrhage may follow this or any other method of prostatectomy. It usually occurs about the tenth day after the operation, being due to the separation of sloughs. It is therefore more common in septic cases than in those which are clean. When the bleeding is only slight no special treatment is required, but if it is sufficient to cause collapse, if the pulse-rate rises, or if there are either obvious clots within the bladder or pain indicating their presence, the first step is to empty the bladder of clots.

It may be necessary to re-open the wound, which is easily done by passing a small straight metal or Hegar's dilator along the line of the suprapubic fistula, followed by increasing sizes until dilatation is sufficient to admit the introduction of either a large self-retaining tube or a straight tube, over which is fitted a Hamilton-Irving or McDonald box. A catheter is then introduced and tied in the urethra, and continuous irrigation is established with warm silver nitrate solution 1 : 10,000, or oxycyanide of mercury 1 : 6,000. This is continued until the hæmorrhage has become minimal and the bladder and prostatic fossa are clean. When the hæmorrhage is severe it is necessary to anæsthetize the patient and pack the prostatic cavity, but this step should be avoided if possible, as it interferes with the treatment of the septic condition which in such cases is almost invariably present. In very urgent cases this can be effected without an anæsthetic, pushing gauze rapidly down into the prostatic fossa and maintaining pressure on it with a pair of sponge-holding forceps introduced through the wound. But for secondary, as for all other forms of hæmorrhage, a hæmostatic bag is preferable. Removal of packing in such cases should be begun after about 48 hours, and completed in about two days, a close watch being kept upon the patient to control further hæmorrhage. Blood-transfusion has special value in such cases, not only to make good the loss, but to promote clotting.

Sepsis in the bladder and prostatic fossa is combated by diuresis, urinary antiseptics, and local irrigations. If severe, continuous-drip irrigation may be used. For this purpose a Hamilton-Irving box is applied to collect the outflow.* Fluid is run in from the irrigator through a catheter which has been passed through the air holes in the lid of the box down into the bladder so that its end lies within the cavity. If a Marion's tube has been used, its side tube can be utilized for this purpose. More efficient irrigation is obtained by inflow through a catheter tied in the urethra. Sepsis can usually be controlled by such measures. Phosphatic deposits are sometimes seen in the abdominal wound—and may be assumed to be also in the prostatic fossa—but only when the urine is septic and alkaline, and irrigation has been inadequate. They are removed by efficient irrigations and giving acid sodium phosphate by mouth.

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* Or, when hæmorrhage has been reduced, a de Pezzer or Malecot tube may be used.

Delayed healing of the fistula is treated by tying a suitable catheter into the urethra for a week or more. It must be carefully adjusted to provide uninterrupted drainage from the lowest part of the bladder. Occasionally it is helpful to apply silver nitrate to the wound or to scrape the wall of the sinus with a sharp curette. If the superficial wound gapes, its edges should be brought together by strapping. In rare instances an operation for the cure of persistent suprapubic fistula may be necessary (*see* p. 2043). The treatment of post-prostatectomy obstruction is described on p. 2099.

Summary.—This operation has the advantage of simplicity, quickness, and the fact that no special instruments are required. But the small incision does not admit inspection of the bladder-cavity ; also it makes the operation difficult if the prostate is not easy to enucleate, the patient is obese, the abdominal relaxation is imperfect, or the surgeon's fingers are short. There is the further disadvantage that when the enucleation has been started hands cannot be changed without fresh gloves. A longer incision of the abdominal wall and bladder, such as that described in a subsequent section, will overcome many of these difficulties. Freyer's operation has been widely practised with great success, and when modified in some minor respects remains for most surgeons the operation of choice.

Use of a hæmostatic bag.—The use of a rubber bag of the type designed by Fullerton (Fig. 1004) or Pilcher (Fig. 1005) is one of the most effective means of arresting hæmorrhage after prostatectomy. The larger tube is led out through the urethra and is used to keep the bag pulled down into the prostatic cavity. The smaller tube comes out through the abdominal wound and is used for inflating and withdrawing the bag. In the best patterns a metal eye forms part of a metal collar attached to the upper end of the larger tube, and through it a double length of strong silk is threaded and tied. The end of this is left lying outside the wound and provides an unfailing means of withdrawing the bag, even through a small wound. It is desirable to have three sizes of bag from which to choose. The smallest has a diameter of 1½ in., the next of about 2 in., and the largest can be distended to about 2½ in. Of these the medium size is the most often employed.

The hæmostatic bag can be used in Freyer's operation, or with a larger abdominal incision. The silk web catheter (18 Coudé or 10 English) through which the bladder has been filled before operation, is left in position until the enucleation is completed ; it will often be found a considerable aid when tearing the urethra across at the level of the verumontanum. Alternatively, such a catheter or a metal dilator about 8/10 English can be passed subsequently. When the prostate has been removed the assistant pushes the instrument far into the urethra so that the beak can be brought to the surface of the abdominal incision. The larger tube which leads from the apex of the bag is pushed over the end of the urethral instrument for about ½ in. A bladder-syringe filled with water is joined to the smaller tube after all air has been expelled from the bag ; air alone may be used, a mixture should be avoided. The assistant now withdraws the catheter, the tube attached to it follows and, when it appears beyond the meatus, he pulls the bag into the prostatic cavity. The surgeon passes two fingers into the bladder while the assistant uses his other hand to distend the bag to the required degree by means of the syringe, the operator deciding when sufficient fluid has been injected. For the bag to function satisfactorily it should be of a size and distension sufficient to make contact with the entire margin of the prostatic inlet, and to press it down into the fossa. A finger is passed round its upper limit to tuck the torn edge of the vesical mucosa down beneath it into the prostatic cavity. When this has been done pressure forceps are applied to the smaller tube to prevent

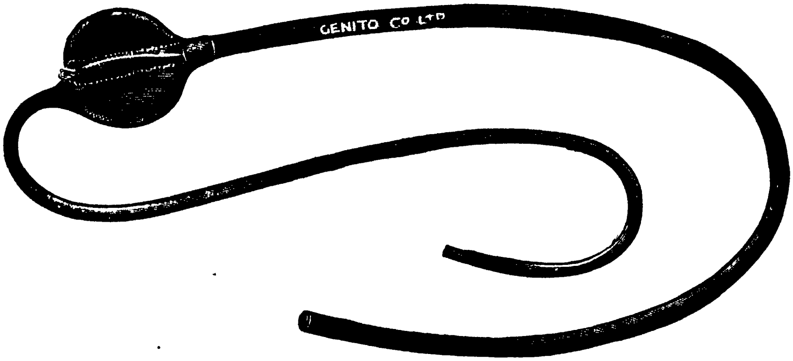

Fig. 1004.—Fullerton's bag.

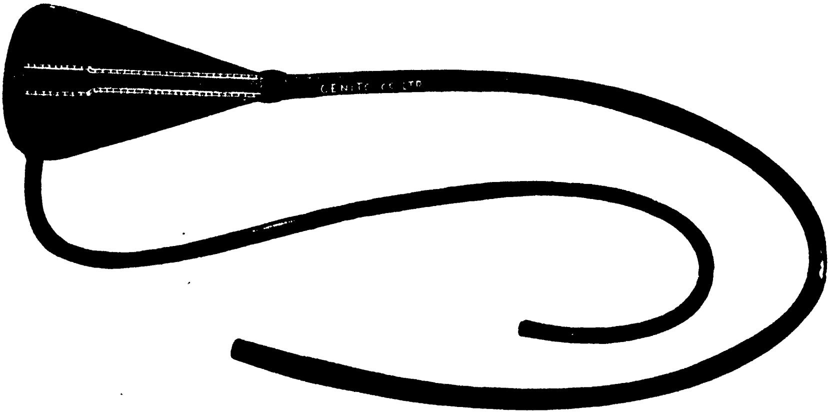

Fig. 1005.—Pilcher's bag.

the escape of fluid, and the syringe is removed. From the time that the bag has been put into position, tension upon the urethral tube must not be relaxed until arrangements have been made for maintaining this permanently.

The bladder cavity is freed from clots and the case is watched for a minute or two, until the surgeon is satisfied that hæmorrhage has been arrested. A straight tube, which need not be more than ⅝ in. in diameter, with two lateral eyes, is placed in the bladder and the wound is closed around it. The tube leading out of the wound from the upper part of the rubber bag is ligatured with strong catgut, folded back on itself and ligatured tightly again. The pressure forceps is removed and the redundant portion of the tube is cut off. The end is left coiled up in the abdominal dressings, and with it lies also the double strand of silk leading from the metal eye on the bag. Instead of a dressing, an Irving box may be applied immediately.

Various means have been employed to maintain tension of the tube leading from the apex of the bag out through the urethra. This must be adequate, but never excessive. Weights or any method of attaching the tube to the bed-frame should never be used. Cabot's crutch may be employed, but the simplest method is to attach the tube to the thigh. A simple and effective measure is as follows: a piece of adhesive plaster about 2 in. wide is passed round the thigh a few inches above the knee, including between it and the skin a piece of strong linen tape, a loop of which, about 1 in. long, is left exposed above the upper margin of the plaster on the inner aspect of the thigh. The lower ends of the tape are turned up sufficiently to be included in a further fold of plaster, and then cut off. The tube leading from the bag is then passed through this loop, folded back and tied to itself, or thus secured with a pair of forceps. When this method is employed the tension on the bag can be relaxed at any time, or re-applied if hæmorrhage should recur.

Removal of bag.—At some interval varying in length from 6 to 24 hours after operation, the wound is examined, and if hæmorrhage has been well controlled the penis is stripped back from the urethral tube, which is then cleansed with spirit, and released from the attachment to the thigh, all pull upon the bag being thus removed. If hæmorrhage recurs this tension can be re-established. Twenty hours after this the tied end of the tube is cut off and the fluid or air is allowed to escape. Four hours later the bag is removed. To do this the stitch holding the suprapubic tube is divided and the latter withdrawn. The penis is stripped back from the urethral tube, which is then cleansed with spirit and cut off close to the external meatus. By pulling upon the double strands of silk and the small tube leading to the bag, the latter is drawn out of the wound. If preferred, the urethral tube can be retained as a catheter for intermittent or continuous irrigation. If this is intended it is not divided at the external meatus but, after the bag has been pulled out of the wound, the tube is cut across immediately below its apex, and then withdrawn to an extent which it is judged will cause its end to lie at the bladder base. It is then fixed to the penis by elastoplast. Immediately the bag has been removed a straight tube similar to that removed should be introduced into the bladder and a large safety-pin passed through the upper end of it. If hæmorrhage has not been well controlled the removal of the bag may be postponed for several days. The remainder of the after-treatment is as described on p. 2054.

Difficulties and complications.—Hæmostatic bags are submitted to very considerable strain, and will perish if kept for long. The pain occasioned by their use is sometimes considerable. They tend to increase septic absorption if the bladder is infected, but are less dangerous in this respect than gauze packing.

Summary.—This method provides a certain and quick means of obtaining hæmostasis, but has disadvantages.

Alban Andrews uses for hæmostasis a large tube with a rubber bag at the end of it (Fig. 1006). This is introduced into the prostatic cavity and distended with ribbon gauze thrust down into it by means of a probe introducer.

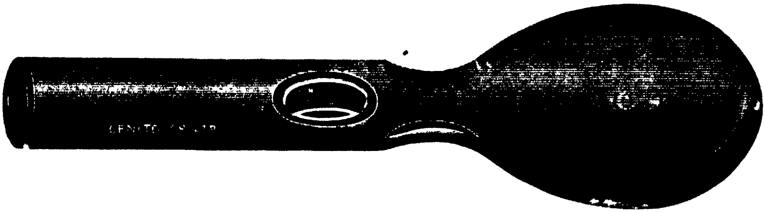

Fig. 1006.—Alban Andrews' tube for hæmostasis.

Prostatectomy by open operation.—Prostatectomy by open operation was recommended and practised by Rutherford Morison as early as 1907.* It was subsequently extensively employed by Thomson-Walker,† and Judd also recommended this method. The bladder is washed out through a silk-web catheter and left distended with eight or more ounces of oxycyanide of mercury 1 : 6,000, or it may be left empty. The catheter is left *in situ*. An incision 4–5 in. in length is made in the middle line from the symphysis pubis upwards. The bladder is exposed and opened, the line of reflection of the peritoneum being carefully observed, and stripped backwards if necessary. One or more fingers of the right hand are introduced into the bladder, and the hand itself, with the exception of the thumb, sinks between the recti muscles into the pelvis. The prostate is then enucleated in the manner described on p. 2053, the urethra being torn across upon the catheter just above the level of the verumontanum. If the prostate is unusually adherent in the region of the vesicle, it can for the moment be left attached at this part, provided the

* "Surgical Contributions," vol. ii, p. 710.

† "Genito-Urinary Surgery," 2nd Edn., 1936.

remainder of it has been freed. In most cases, however, the enucleated prostate is easily delivered into the bladder and so withdrawn from the wound. As this operation is performed without the aid of fingers in the rectum, it is necessary to palpate the wall of the prostatic cavity with particular care to ensure that no separate adenomata have been left behind. A catgut suture is passed through each side of the bladder-wound. The patient is now placed in the Trendelenburg position and a self-retaining retractor introduced; Thomson-Walker's, Swift Joly's, H. Harris's, or Morson's, the last two being illuminated, may be employed (Figs. 1007, 1008). An assistant holds up the anterior edge of the bladder against the symphysis pubis with a special S-shaped retractor. The bladder and prostatic cavities now come into view. If the prostate is still adherent in the region of the

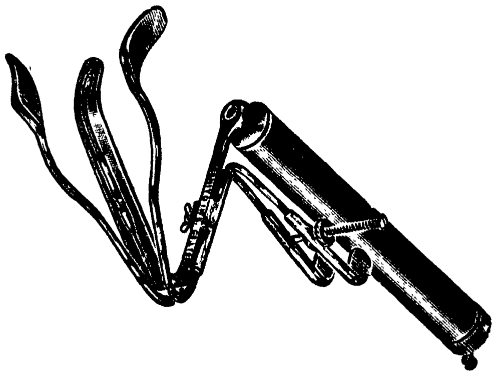

Fig. 1007.—Morson's illuminated anterior retractor and speculum.

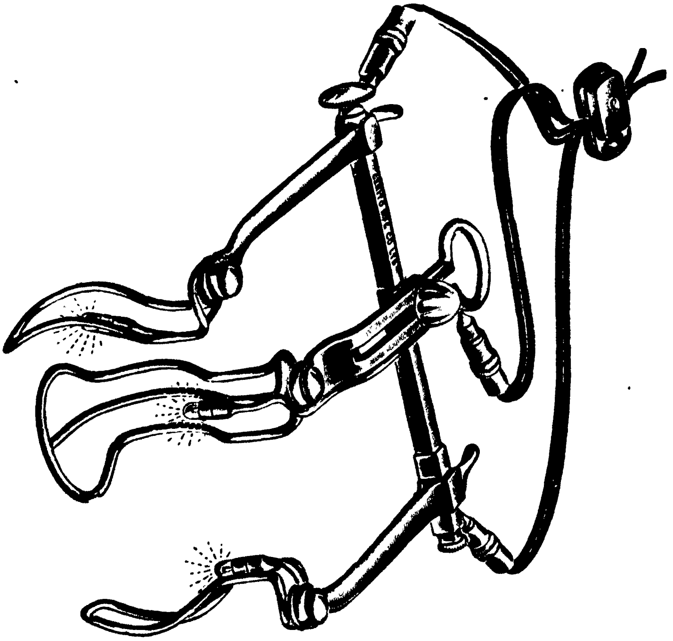

Fig. 1008.—Morson's self-retaining illuminated bladder retractor.

seminal vesicles or bladder-neck, it should be removed by cutting with strong curved scissors, but should first be lifted well up into the bladder to prevent injuring the rectum. If bleeding is profuse, the prostatic cavity is temporarily packed with one or more gauze swabs, a careful count being kept of the number. Arterial bleeding comes from the brim of the prostatic fossa and also from vessels deep down within the prostatic cavity. There is commonly, also, considerable venous oozing. Arteries, if present at the prostatic inlet, are usually in its posterior part, often about 30° to right or left of the middle line, and just beneath the mucosa. They may be picked up with long pressure forceps and tied, or secured by a stitch of No. 0 plain catgut in a fully-curved needle passed from within the prostatic cavity, picking up the pathological capsule, the sphincter and the vesical mucosa just behind the vessel. If no individual vessel in this region claims immediate attention, all tags of tissue are cut away from the entrance to the prostatic cavity, and if any strips of false capsule remain partially detached within the cavity, these are picked up with sponge-holding forceps and removed by twisting. Thomson-Walker, when introducing this operation, aimed at the arrest of hæmorrhage and the prevention of post-prostatectomy obstruction. If his technique is followed, the suture of the prostatic inlet is now commenced ; it may be interrupted or continuous, the latter being most usual. No. 0 plain catgut should be used on a fully-curved needle held in a needle-holder. The suture is begun in front of the mid-coronal line on the right side, and passes round the margin to finish in the same position on the left side. The points of insertion of this suture should not be too far apart, for if so they would, when drawn tight, act as a purse-string. The sutures take up the bladder mucosa, the bladder sphincter, and a layer of prostatic capsule, and should take a good bite of the tissues. The assistant holds the suture under slight tension so that the edge is raised up and the stitching facilitated. If, after the suture is complete, bleeding is still going on from the walls of the cavity, the catheter is drawn up so that its eyes lie within the bladder, and the prostatic cavity is packed around it with iodoform gauze. A drainage-tube similar to those used in Freyer's operation is introduced, and the bladder retractors are replaced by self-retaining or other retractors to hold apart the abdominal wall. The bladder is sutured, beginning at the part nearest to the internal meatus. The stitches should be interrupted or continuous of No. 1 plain catgut. The tube is brought out of the bladder at the top of the incision and the stay-sutures are withdrawn. The abdominal wall is closed as after cystotomy (p. 1986), a piece of corrugated rubber leading down to the prevesical space. If satisfactory hæmostasis is not obtained and gauze packing has to be used, the end of this is brought out of the wound between the corrugated rubber and the bladder drainage-tube. The catheter is now tied in the urethra with tapes and adhesive plaster.

After-treatment.—A Hamilton-Irving or S. McDonald box can be applied, or a dressing of gauze and sterile cellulose. In other respects the care of the patient is as described on p. 2054. Packing is removed after forty-eight hours. The corrugated rubber is removed on the second or third day, the bladder tube on the fifth or sixth day. The catheter is removed at the end of a week, when it can be replaced by one of the de Pezzer type inserted suprapubically. The de Pezzer tube is removed when hæmorrhage has ceased completely and the sepsis, if present, has become slight. A catheter may be tied in about the fourteenth day to encourage closure.

The **advantages** of the operation are that enucleation of the prostate is facilitated by the large incision and can be undertaken successfully even if abdominal relaxation is not complete. If no preliminary cystoscopy has been undertaken, the large incision affords an opportunity for inspection of the bladder-cavity, and retractors should, therefore, be introduced before the prostate is enucleated ; thus, such conditions as small or translucent calculi, growths or vesical diverticula will not be missed. Removal of tags tends to minimize sepsis due to the formation of slough, and the sutures at the prostatic inlet in some cases have hæmostatic value. Prostates which present difficulties to enucleation can be excised with scissors under vision.

Difficulties and complications.—The operation takes more than twice as long as that of Freyer. In subjects who are short and obese the exposure of the prostatic inlet is poor and the introduction of sutures difficult, particularly if hæmorrhage is profuse. A long incision is not well tolerated by bronchitic subjects. Unfortunately in many cases the arrest of hæmorrhage obtained by this means is very imperfect. The arterial bleeding from the margin of the prostatic cavity is controlled, but not infrequently arteries can be seen spurting within the prostatic cavity, usually half way down on either side, and the operation does nothing to control these or the venous bleeding within the cavity. In a considerable proportion of cases some form of packing is necessary. It is unsatisfactory to have to pack at the end of a severe operation which has been conducted particularly with a view to arresting hæmorrhage by suture.

Summary.—This operation has the advantage that a general examination of the bladder can be carried out, that access to the prostate and its enucleation is facilitated, and that in difficult cases the operator can use his hands alternately. It has the disadvantages that it takes longer to perform, does not necessarily arrest hæmorrhage unless the cavity is packed, and does not absolutely prevent post-prostatectomy obstruction.

Prostatectomy with closure (H. Harris's operation).—The essential aims of this operation, in the words of the late H. Harris, are : " The immediate control of hæmorrhage by suture, the reformation of the prostatic cavity, combined with immediate closure of the bladder and abdominal wounds. This operation completely obviates recurrences or postoperative obstruction." * This surgeon laid great stress upon the preliminary preparation, in particular on surgical cleanliness; " . . . any slovenliness in this regard, apart from immediate effects, will reap its own harvest of septic sequelæ." This is only too true.

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* Harry Harris, " Prostatectomy with Closure : Five Years' Experience," *Brit. Med. Journ.*, Jan. 1934, i, 434.

Preliminary catheter drainage is employed for at least ten days if the urine is dirty, or if the residual urine exceeds 4 oz., or if renal function is below normal. If a retained catheter is employed, the bladder is washed out once or twice daily with permanganate of potash solution of 'pale pink colour,' then with sterile water, and emptied. Four ounces of 1 : 3,000-solution of silver nitrate is run into the bladder, and the catheter is clamped for half an hour. The catheter is drained into a bottle at the bedside, and is changed at least every third day. Urinary antiseptics are administered. Harris claimed that: "few even badly infected bladders cannot be very efficiently cleaned up by these measures." But his writings do not include any reports upon the bacteriology and microscopy of the urines in his cases of prostatectomy. It is, however, certain that if this method of prostatectomy is to be employed every endeavour should be made to get the urine sterile and to keep it so, for this operation differs from all others upon the prostate in that stitches are left in position which pass from the lumen of the bladder out into the cellular tissues of the pelvis, and clearly these may act as channels along which sepsis may spread from within the urinary tract and lead to pelvic cellulitis.

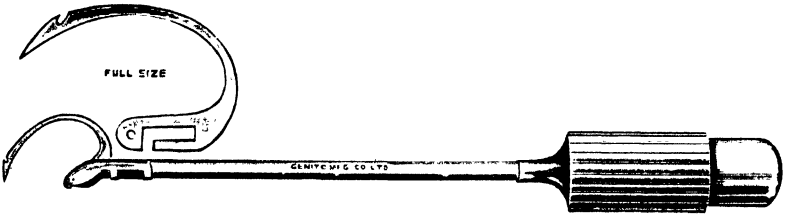

Fig. 1009.—Boomerang needle-holder.

Special instruments.—Boomerang needle-holder (Fig. 1009); one large and one small needle; ligature carrier; and illuminated bladder retractors (Morson's illuminated anterior bladder retractor (Fig. 1008) is a very useful addition).

Operative technique.—The bladder is thoroughly washed and emptied, and the urethra irrigated. A transverse incision is made through the skin and fat 2½–3 in. in length and 1 in. above the symphysis pubis. The rectus sheath is opened vertically and the recti separated. The bladder is opened at the highest point and the prostate enucleated. Two fingers are introduced into the rectum, as described in Freyer's operation (p. 2053). Harris employed the method of enucleation first described by Bently Squier. When the prostate has been delivered a self-retaining illuminated retractor is introduced (Fig. 1008). Attention is now given to the prostatic rim. Tags are resected and individual hæmostatic sutures of the type described on p. 2063, are inserted, using the boomerang needle-holder fitted with the smaller-sized needle (Fig. 1009). On each side one of these may be left long and held in pressure forceps to lift the prostatic rim and thus facilitate the insertion of succeeding sutures. Every

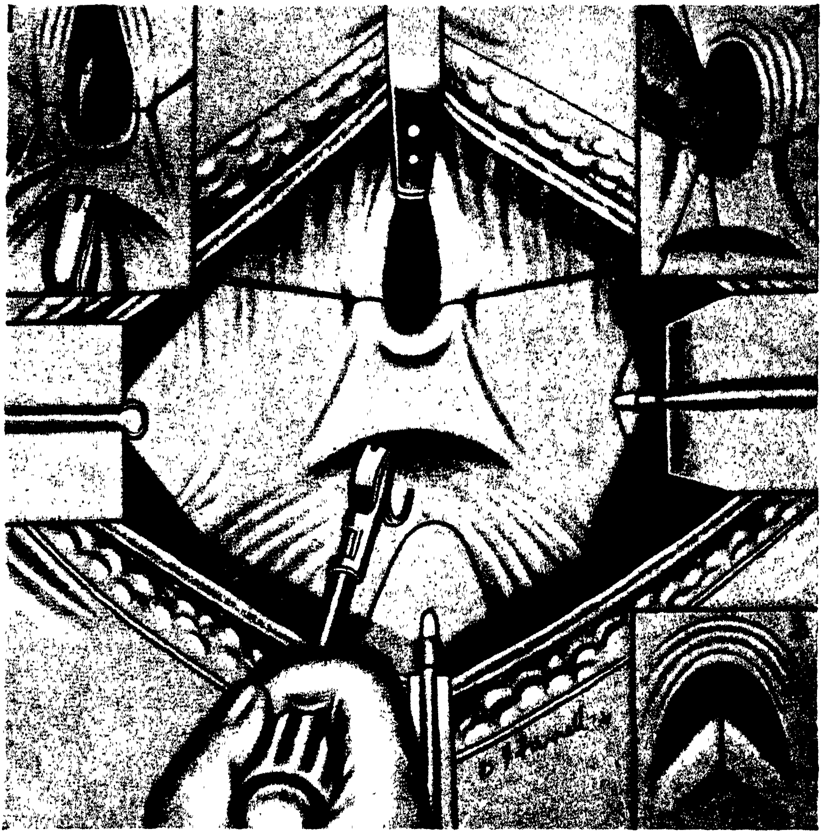

Fig. 1010.—Retrigonization of the prostatic urethra. The main figure shows the point of entry of the needle in the bladder base well down behind the inter-ureteric bar.

Insert 1 shows the point of emergence of the needle well forward in the prostatic cavity and the suture carrier approaching the needle. *Insert* 2 shows the retrigonization suture being tied, with the forefinger of the left hand pressing the loop well down into the prostatic cavity. *Insert* 3 shows the retrigonization suture tied, sewing the trigone well down into the prostatic cavity, both obliterating the ledge in this situation and re-forming, at least in part, the new prostatic urethra. Two hæmostatic sutures only are illustrated in all figures for the sake of simplicity.

endeavour is made to control hæmorrhage from this region, but this result will not always be easily obtained.

"**Retrigonization.**"—For this the larger needle is used in the boomerang needle-holder. It is entered at the deepest part of the '*bas fond*' behind the inter-ureteric bar (Fig. 1010). The point of emergence of the needle is well down through the floor of the prostatic cavity, and as the handle of the holder is compressed the needle-point emerges in the middle line at the prostatic inlet. The suture carrier, equipped with a piece of No. 3 plain catgut about 14 in. long, is brought into contact with the needle, and the catgut engaged in the slot. As the pressure upon the spring-handle is relaxed, the catgut is released from the suture-carrier. The handle of the needle-holder is swung forward towards the symphysis pubis and, with a little manipulation, the needle bearing the thread is withdrawn from the wound. The suture is tied by a running knot, with the point of the index-finger of the left hand. This is pushed well down into the prostatic bed. Two more knots are then added, the first tightening up the running knot, the second securing it. Before inserting this or any other suture at the edge of the prostatic fossa, either for hæmostasis or for reconstruction, it is essential to be certain of the exact position of each ureter. It is claimed that by this suture the trigone is brought well down into the prostatic bed, and thus re-forms the floor of the prostatic urethra.

Anterior obliterative sutures.—Using the large boomerang-needle the point is entered on the left side 1–1½ in. from the free edge of the prostatic rim, depending upon the size of the cavity (Fig. 1011). While this is being inserted, the handle end of the needle-holder is, in a combined movement, swung from the opposite edge of the wound towards the side of the operator and the spring compressed, thus causing the point to emerge at a similar site through the bladder mucosa on the right side of the prostatic inlet. When inserting this the needle-holder should be kept in a nearly vertical plane, because if used in a more horizontal position there is a risk of picking up the triangular ligament and injuring the compressor urethræ. It may be necessary to push slightly upon the mucosa to cause the point of the needle and the slot in it to appear above the tissues. The suture-carrier, equipped with a 14-in. length of No. 2 plain catgut, is now engaged in the needle-slot. Synchronously the spring-handle and suture-carrier are released. As the needle retraces its course, the hand is swung across to the right side of the wound. This movement, combined with a series of light jerks, is usually sufficient to allow it to be withdrawn. Occasionally a little pressure with a pair of forceps on the mucosa at the neighbourhood where it was entered will be necessary to clear it. The suture, tied with a running-knot pulled moderately, but not too tightly, is secured by two succeeding knots, and then is held with forceps. This first suture passes transversely at a tangent to the anterior segment of the prostatic rim. A second is introduced parallel to the first and bisects what remains of the

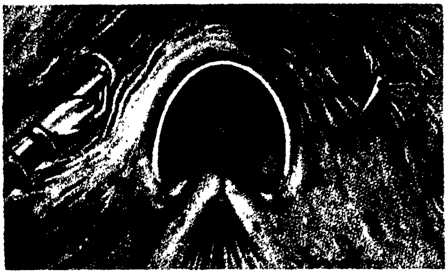

Fig. 1011.—Needle in position for the first anterior transverse obliterative suture.

Note width of bite of needle. Trigonal tongue in position. For simplicity, only two hæmostatic sutures are shown.

prostatic cavity (Fig. 1012). These sutures traverse the prostatic cavity deeply from side to side, just missing the floor in its depths. They will lie above and in front of the catheter when it is passed. Very rarely a third may be required. When they are tied, no raw surface is visible, though the prostatic urethra should always be left open wide enough to admit the tip of the first finger.

A special thin-walled rubber catheter with two eyes (size 22 French, 12 English) is introduced. Some difficulty may be experienced in passing it into the bladder, and it may be necessary to thread it over an introducer. The tip is cut off, and the lip transfixed with a long strand of medium-thickness silkworm gut, the ends of which are brought to the surface of the wound and temporarily secured in a pressure forceps. The bladder is now swabbed out and, if hæmorrhage has been adequately controlled, may be completely closed, the ends of the strand of silkworm gut alone coming out through it to the surface; this is adjusted to maintain about 1 in. of the end of the catheter within the bladder-cavity. At the end of the operation the catheter suture is tied round a small metal or glass rod, which lies upon the skin.

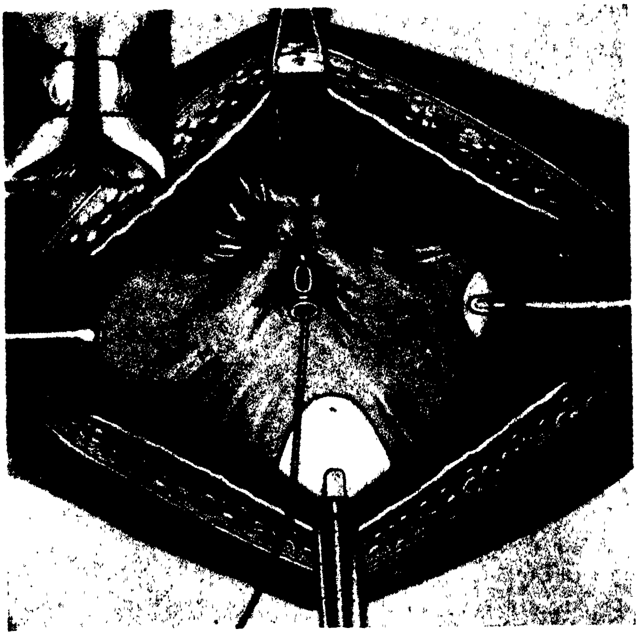

Fig. 1012.—Second transverse obliterative suture inserted ; plastic operation completed.

The catheter, with silkworm-gut transfixion suture, is in position. It is passed intact and the tip cut off after a second eye has been made.

Inset.—Same stage before passage of catheter. Note that there is no visible raw surface, that the trigonal flap lies on a plane below that of the rest of the bladder base and is firmly bedded in position, and that the lateral edges of the prostatic rim are deeply inverted, thus partly re-forming the side walls of the new prostatic urethra.

In closing the bladder and the abdominal wall, Harris employed a special three-looped suture which traversed the rectus and its sheath on one side, picked up the outer layer of the bladder on the opposite side, and then crossed again to the original side and picked up the muscular and submucosal layers of the bladder. The other end of the suture is inserted in a similar manner but reversed. This stitch is designed to cause a valvular inversion of the cut edges of the bladder, and to obliterate the cave of Retzius. A few subcuticular sutures of No. 0 catgut are inserted and the skin-wound is closed with Michel clips. Before leaving the table, the catheter is syringed out with 1 : 3000 silver nitrate to remove blood-clot. The end is inserted into a sterilized 8-oz. glass bottle. When the patient is returned to bed the catheter is connected up by a length of rubber tubing leading to a bottle at the bedside, the end of the tubing dipping under the surface of an antiseptic solution. Unless haæmorrhage has been adequately controlled, the bladder should not be completely closed, but suprapubic drainage through a Winsbury White or de Pezzer tube provided.

After treatment.—A careful watch must be kept on the catheter to ensure that drainage is continuous. If in doubt, it should be syringed with antiseptic solution every half hour until drainage is satisfactory. The catheter is removed on the tenth day by lifting the rod from the abdominal wall and cutting across both ends of the silkworm gut, when the hairpin-shaped remnant comes away with the catheter.

Modifications.—A vertical midline abdominal incision may be used, as described on p. 1981 ; it has the advantages there enumerated. Most surgeons who have performed this operation have found that it is the transverse obliterative sutures which do most to arrest hæmorrhage, and it is therefore unnecessary to insert hæmostatic sutures of the Thomson-Walker type unless an obvious vessel is spurting, particularly since a boomerang needle is more apt to produce hæmorrhage than are the smaller ones commonly used in other operations.

Many surgeons prefer not to close the bladder completely, but always provide drainage through a suprapubic tube. Continuous irrigation may usefully be combined with this. Morson, using his anterior illuminated blade and speculum, aims at uniting the tip of the trigone to the torn end of the prostatic urethra. To close the prostatic fossa he uses a figure-of-eight inverting suture in front of the catheter.

Difficulties and complications.—The transverse incision of Harris cannot be easily extended, as is possible with a vertical incision, should any unexpected condition be met with in the bladder, and in obese subjects sometimes renders enucleation of the prostate unnecessarily difficult. Moreover, the exposure obtained is strictly limited, and the insertion at the bladder-neck of the special sutures may be found far from easy. The operation should never be employed in the presence of obvious sepsis on account of the grave risk of pelvic cellulitis or septicæmia ; this may occur even when the urine was sterile before operation, if sepsis should develop subsequently.

Hæmorrhage.—There is always a chance that the sutures may fail to control hæmorrhage, and the need for attention to drainage from the catheter during the period immediately succeeding the operation has already been mentioned. If the bladder has not been closed, careful syringing at short intervals will in most cases suffice to keep the tube and catheter clear until the hæmorrhage subsides. Continuous irrigation may be useful. When the bladder has been closed, it is still more important to prevent the accumulation of clots. If they form, the bladder must be opened and a tube inserted. To effect this the abdominal dressings are removed and the rod to which the suture supporting the catheter has been tied is lifted up sufficiently to pull the end of the catheter, and with it the opening in the bladder-wall, into close proximity with the deep surface of the abdominal incision. A pair of pressure forceps, and subsequently a finger or a Marion's dilator, is inserted along the line of the suture to enter the bladder. As soon as this has been done a gush of blood-stained fluid comes from the bladder. A suitable drainage-tube can now be inserted, and syringing is continued until all clots have been evacuated ; continuous irrigation may then be substituted. The special three-looped suture which Harris employed for closing the bladder and abdominal wall was designed partly to facilitate such re-opening of the bladder if it should become necessary.

H. Harris* stated that post-prostatectomy obstruction never follows this operation, but it has occurred in the hands of other surgeons following his technique.

Summary.—This operation has the advantage that hæmostasis is more perfect than can be obtained by any other means. Patients are much more comfortable when the abdomen is closed either entirely or so that only a small suprapubic tube comes out of the lowest part of the incision. It has the disadvantages that special instruments are required, it is not easy to perform, and pre-existing or subsequent sepsis may produce disastrous results which are not seen with any other method.

SUPRAPUBIC PROSTATECTOMY IN TWO STAGES

Indications.—This procedure is indicated: (1) when there is impairment of renal function which cannot be successfully treated by catheter drainage ; (2) in the presence of sepsis in the bladder or kidneys which does not respond to such treatment ; or (3) if retention of urine is present and for any reason its treatment by catheterization is impossible. One-stage prostatectomy under these conditions may prove fatal, and even cystostomy carries a very high risk, but if the patient survives this, subsequent prostatectomy can in many instances be performed when the general level of health, renal function, and urinary infection have been materially improved. Improvement of renal function often occurs in three or four weeks, but sometimes is delayed for several months, and in some instances the recovery is never sufficient to justify a prostatectomy. The most important indications of a recovery of kidney function and an improvement in the patient's general condition are a moist, clean tongue, recovery of appetite, loss of thirst and a general return of mental and physical well-being. The blood-urea usually falls to normal, but in some cases remains at 60 mgm. per 100 c.c. or over. This of itself is not a contra-indication to prostatectomy if the urea-concentration test becomes good. The urine in septic cases does not become sterile but, from being previously pale and grossly turbid, becomes of good colour and, in many instances, clear except for flakes of muco-pus.

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* Harry Harris, "Prostatectomy with Closure : Five years' Experience," *Brit. Med. Journ.*, Jan. 1934, i, 434; "Prostatectomy with Closure : Addenda and some Observations," *Brit. Med. Journ.*, April, 1936, i, 816.

Prostatectomy in two stages has the advantage that shock in many cases, though by no means always, is reduced. When the prostate is enucleated at a secondary operation the amount of bleeding is usually diminished, as during the period of bladder drainage the gland often shrinks considerably and becomes less vascular. It should not, however, be assumed that serious bleeding will not occur. The disadvantages of this procedure are the need of two operations and two anæsthetics, and the increased length of time in hospital or nursing home. The enucleation and delivery of the prostate is more difficult owing to scar-tissue in the abdominal wound, and there is some risk of post-operative hernia.

Treatment between the two operations.—If the interval is longer than three weeks—and it is only rarely advisable to perform prostatectomy earlier—a de Pezzer tube (Fig. 976) should be inserted and the patient allowed to get up.* If the drainage is to continue over long periods it may be necessary to replace this by permanent drain apparatus (*see* p. 1986). In either instance the local treatment is as described on p. 1986. If there is considerable sepsis the bladder should be washed out thrice in the twenty-four hours, or continuous irrigation should be installed, the fluid being run in through a tied-in catheter.

Freyer's operation in two stages.—If an interval of only a week or ten days has passed since the cystostomy was performed the wound is easily re-opened throughout its length. If necessary it can be extended. When, however, the original incision has healed, with the exception of the fistula—and this will usually be the case—fresh dissection is necessary.

If the tube inserted at the preliminary cystostomy was brought out of the abdominal wall 2 in. or more above the symphysis pubis, and if the patient is not fat and scar-tissue is not abundant, it is possible, after the tube has been withdrawn, to enlarge the incision sufficiently by passing a scalpel down the sinus and cutting through all the tissues of its wall towards the symphysis pubis. Two fingers of the left hand are then introduced into the rectum and a finger is passed through the sinus to the prostate, which is enucleated. In many cases this is not easy, as scar-tissue makes this part of the abdominal wall unyielding, and if the patient is fat it may be extremely difficult, even when the prostate is pushed well up from below. Attempts to enucleate the prostate through too small an incision may lead to tearing the peritoneum. It is therefore better to *excise the scar*. To do so the line of this in the skin should be extended towards the umbilicus for an inch or more and deepened, for above the scar the layers of the abdominal wall can be differentiated. The rectus sheath is opened, and the muscles are identified and separated and lifted up from the extraperitoneal tissues. Partly by blunt dissection and partly by cutting with scissors or a knife, the wound is opened in the middle line down to the fistula. It will often be necessary to resect some of the scar-tissue. Dissection is carried round the fistula on both sides down to the symphysis pubis, and the track is thus detached from the remainder of the abdominal wall. During this process careful attention must be paid to the position of the peritoneum, as this is often closely adherent both above and lateral to the point where the fistula enters the bladder. Injuries to the peritoneum are avoided by deliberate dissection, full retraction of the abdominal wall, and transverse cuts with the points of curved scissors or a knife, while the assistant pushes the peritoneum gently upwards. When the fistula is freed it is cut away from the bladder-wall, beginning on the aspect nearest to the symphysis pubis and working upwards to the neighbourhood where the peritoneum may be still attached. When this has been done the opening is dilated and a finger introduced into the bladder hooks the viscus up out of the wound. The freeing of the peritoneal reflexion is continued by cutting transversely until sufficient of the bladder-wall is exposed to permit adequate incision through it vertically. If the peritoneum is accidentally opened, the region should be protected by gauze, and the dissection continued until the bladder is sufficiently free. The peritoneum is then closed with a continuous suture of No. 1 catgut and allowed to fall back. It is always wise to examine the peritoneum after the enucleation, since it may be torn during this procedure.

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* Or Riches' method may be used (p. 2044).

The prostate is then enucleated and the remainder of the operation is as described on p. 2053. In closing the abdominal wall it may be necessary to define by dissection the various layers where they are involved in scar-tissue, and perhaps to under-cut the skin, but as a general rule the less dissection the better, as it lays open fresh areas in which infection may develop. The layers should be sewn up carefully and separately, and a firm bandage applied. Stitches in these cases are likely to cut out and the skin-edges to separate ; for this reason a suprapubic box is best avoided.

Complications.—Hæmorrhage, though usually slight, may in some cases be severe enough to require packing with gauze or the use of a hæmostatic bag.

Open operation in two stages.—Open operation is not easily performed when the bladder has been drained by cystostomy for, apart from the need of wide excision of the scar and freeing the bladder, the latter is temporarily contracted, and this makes difficult the use of self-retaining retractors. To mitigate this it is desirable for a week before operation to plug the cystostomy tube for periods of two or three hours to regain bladder distensibility. The approach to the bladder is described on p. 2061.

H. Harris's operation in two stages.—The preceding remarks apply equally to this operation when conducted in two stages. Harris, using his transverse incision, advised that in this case it should be placed 2 in. above the symphysis pubis for the purposes of the preliminary cystostomy. Prostatectomy should not be undertaken until at least one month after cystostomy, in order to allow subsidence of wound induration. The bladder is approached through a vertical incision carried downwards to the pubes from the cystostomy opening. After sutures have been introduced in the manner described on p. 2066. primary closure may be undertaken, but this is more difficult than when the operation has been conducted in one stage.

Summary.—Freyer's is the operation of choice for prostatectomy in two stages, for the reasons that wide exposure of the bladder is not easy and hæmorrhage is not commonly severe. If necessary, it can be combined with the use of a hæmostatic bag.

Results of supra-pubic prostatectomy (St. Peter's Hospital Reports).—

	Number	*Deaths*
1901–1937.		
Total number of suprapubic prostatectomies, in one or two stages	3621	366 (10.10 per cent.)
1928–1937.		
Suprapubic prostatectomy in one stage .	928	93 (10.02 ,, ,,)
Suprapubic prostatectomy in two stages	230	30 (13.04 ,, ,,)

The increase in the mortality rate when the operation was performed in two stages indicates that cases treated by this method were considerably poorer operative risks.

Mortality of suprapubic prostatectomy.

Sir Peter Freyer (" Enlargement of the Prostate," 1920, p. 150), 1625 cases, 87 deaths, 5.3 per cent.

Sir John Thomson-Walker (" Modern Operative Surgery," 2nd Ed.), 472 private cases, 25 deaths, 5.2 per cent.

S. H. Harris (*Brit. Journ. Surg.*, 1933, XXI, 434), 413 cases, 11 deaths, 2.7 per cent.

PERINEAL PROSTATECTOMY

The names of Goodfellow and Alexander (1896) in America, Nicoll (1894) in this country, and Gosset (1900) in France are associated with the development of perineal prostatectomy. Proust (1900), by his careful description of the anatomy and technique of the perineal route, and Young (1903) by his modification and continued advocacy of perineal prostatectomy, of which he has very wide experience, have placed this operation on a sound and scientific basis.

Perineal prostatectomy is the operation always chosen by some surgeons for the treatment of benign enlargement of the prostate. In this country it has, however, never been so widely used as suprapubic prostatectomy, and the majority of surgeons, being more familiar with the latter route, will either not use the perineal route at all, or reserve it for specially selected cases.

Advantages.—The abdominal wall is left undisturbed. This is a great benefit to certain patients, particularly those suffering from chronic bronchitis. Any incision into the abdominal wall has the disadvantage of temporarily limiting its movements in respiration and, as a result, excursions of the diaphragm also become restricted. Diaphragmatic movement is further hampered by intestinal flatulence which is not infrequent, particularly if renal function is temporarily disturbed. In many old subjects the respiratory movements of the chest are always below normal and, when circumstances impair the descent of the diaphragm, the volume of tidal air becomes further reduced and stasis in the pulmonary bases results. This state of affairs is always produced in some degree by decubitus. Furthermore, since coughing produces pain or discomfort in the region of the abdominal incision, the bringing up of sputum is made more difficult. When the prostate is approached through the perineum the patient is able to breathe deeply and to cough freely ; also the passage of flatus is facilitated because the abdominal musculature is intact. For these reasons patients who would probably not survive suprapubic prostatectomy may sometimes be successfully treated by the perineal operation. A further advantage is that at the conclusion of the operation the catheter or tube employed can be so placed that it provides drainage from the lowest point of the bladder.

Disadvantages.—The operation is more difficult, and lack of skill may easily cause injury to the rectum or permanent urinary incontinence. Complications within the bladder, such as a very large intravesical projection or stones, are not easy to deal with and very large prostates are also difficult to remove. It is, of course, an unsuitable method when a co-existing bladder growth or diverticulum requires treatment.

When prolonged preliminary bladder-drainage is required cystostomy becomes necessary, and when the patient's condition becomes good enough to justify prostatectomy this will usually be undertaken by the suprapubic route, though subsequent perineal prostatectomy is not precluded.

Technique.—The perineum is prepared, the bladder washed and emptied, and a 10/12 steel bougie put in the urethra. The patient is placed in the exaggerated lithotomy position. The lower end of the table is fully elevated, the pelvis placed on a rest, and the thighs and knees are held by leg-rests and the shoulders by shoulder-rests. The perineum is thus almost or completely horizontal, with the legs vertical and the thighs horizontal.

A small towel is sutured or clipped to the skin to cover the region of the anus. A curved incision is made across the perineum from 1 in. just in front of one tuber ischii to the same position on the opposite side, with its convexity forwards, the centre of the curve being 1½ in. in front of the anus. The incision is carried through skin and subcutaneous fat, so that the convex flap is displaced backwards, exposing the bulb covered with the bulbo-cavernosus muscles. Behind this in the median line is a fibro-muscular band, the superficial ano-bulbar raphé, which connects the bulb with the sphincter ani externus. Blunt dissection is made on either side of this with the fingers, the handle of the knife or curved Mayo scissors to define the central point of the perineum. Spurting vessels are clipped and tied at once, as pressure forceps in the wound impede the dissection. A special bifid retractor may now be inserted to make the raphé still more obvious. The latter is now cut across close to, but without injuring, the bulb. The bifid retractor is then no longer required and for the remainder of the operation a smooth right-angled retractor is used, the blade being about 1½ in. wide and 3 in. long. It should not have a curved lip, as this might produce a tear of the bowel. Blunt dissection is now continued on either side. The two forefingers open up the space between the levatores ani laterally, the posterior borders of the transversi perinei anteriorly and the rectum posteriorly. Throughout the dissection great care must be taken to avoid injury to the bowel; the fingers therefore work outwards and forwards, but not backwards. Some surgeons during this and the next stage keep the left forefinger in the rectum as a guide until the bowel is entirely freed. The glove is then changed.

In the middle line and on a much deeper plane than the raphé, the dissection sometimes exposes the recto-urethralis muscle. This often is an ill-defined band of tissue, but it is of great importance, for it unites the rectum to the bulb and maintains the angle which exists at the junction of the rectum and the anal canal. Until it has been divided, the necessary posterior displacements of the bowel cannot be begun, nor can the membranous urethra be exposed. When a clear exposure of this tissue has been obtained it is divided by careful cutting with the scissors, keeping well forward of the rectum, which is not yet defined or obvious. It is equally important not to injure the urethra. Its position can be determined by feeling for the steel bougie within it. The rectum is by now sufficiently displaced backwards and held there by the retractor for the membranous urethra to be located. The blunt dissection is again resumed in a forward and outward direction, working gradually upwards towards the lateral aspects of the posterior surface of the prostate. This cannot be fully exposed until Denonvillier's fascia has been dissected. The anterior layer of this is whitish; it is a constituent of the anatomical prostatic capsule, and must therefore be displaced forwards. The posterior layer is not so well defined; it is attached to the rectum. The space between these two layers must be opened up to complete the backward displacement of the bowel. This is achieved by careful backwards retraction while the strands of tissue uniting the two layers are divided with scissors. The depth of this dissection from the surface is considerable and, as it must always be done under vision, good illumination is essential. Two narrow retractors on either side of the wound are useful. When completed a finger is again introduced and it will now be found easy to clear the whole posterior aspect of the gland.

An incision is made through the capsule and substance of the gland, ¾ in. above the apex of the gland, and therefore well away from the membranous urethra (Fig. 1013). The knife cuts transversely in the middle line on to the bougie, and while doing so is pointed upwards and forwards. When the steel bougie has been felt with the knife, the incision is lengthened for about ¾ in. in a horizontal direction. Thus the anatomical capsule, the false capsule, the substance of the benign enlargement, and the mucosa of the prostatic urethra have been incised. The first two structures are closely fused and their cut edge is picked up with dissecting forceps to draw them away from the "adenoma" within. The plane of cleavage is then opened up for a short distance all round the incision with a blunt dissector or with the points of Mayo scissors.

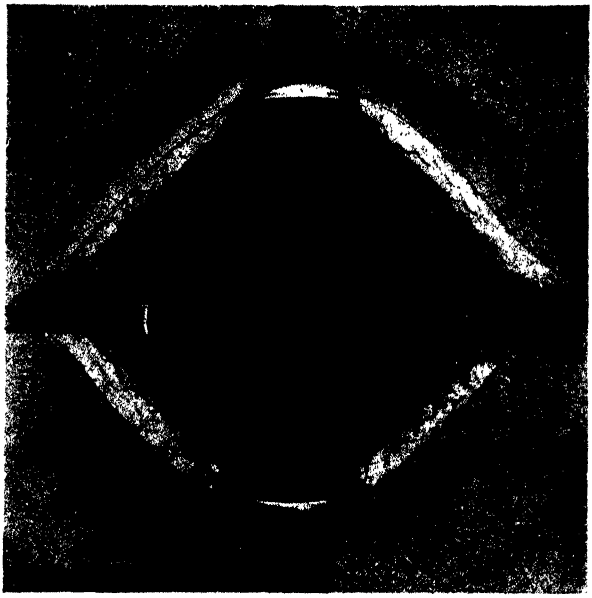

Fig. 1013.—Perineal prostatectomy.

The prostate has been exposed and a transverse incision made for the introduction of Young's catheter.

The tip of a finger is introduced to ensure that the steel bougie can be felt. This is then withdrawn and a straight metal dilator, size 30 Charrière (18 English) is passed through the opened prostatic urethra in an inward and slightly upward direction to enter the bladder, thus ensuring that the passage is clear. This is withdrawn and replaced by Young's prostatic tractor (Fig. 1014). In introducing this the blades are closed and the beak which they form is kept upwards, aiming in the direction of the abdominal wall just above the symphysis pubis. When well within the bladder the screw is loosened, the blades are opened to lie transversely, and the screw is then tightened again. By this instrument the prostate is drawn steadily towards the perineum during enucleation. The plane of cleavage can be further opened up with a blunt dissector or scissor points, but it is usually completed with the finger. First one and then the opposite lateral lobe is freed and drawn out into the perineum, the last portion of the enlargement to appear being the intravesical projection. This is separated from the internal sphincter and trigonal mucosa by the same process. It is in this region that most difficulty is experienced; firm bands of tissue on each postero-lateral aspect have to be torn through, and arteries requiring ligature are sometimes found. A finger-tip is passed into the bladder to ascertain that the way is clear, and then a scoop to search for and remove any calculi which might have been concealed from cystoscopic view by the intravesical projection of the prostate.

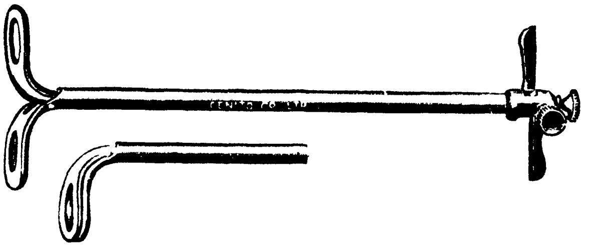

Fig. 1014.—Young's prostatic tractor.

A 24 Charrière (14 English) coudé silk web catheter is passed along the penile urethra, washed through and adjusted so that the beak and eyes lie well within the bladder-cavity. The incision in the capsule of the prostate is closed with interrupted sutures of No. 1 plain catgut, but not so closely that if hæmorrhage occurs the blood cannot find a way out into the perineum. A drainage-tube ⅜ in. in diameter is placed in position with its end close to the suture-line, and brought out of the perineal wound and stitched to the skin well to one side of the middle line. Closure is completed with a few catgut sutures through the fat and subcutaneous tissue, with fine salmon-gut for the skin. The catheter is again washed out and then tied in position.

After-treatment.—A careful watch is kept on drainage through the catheter, which is syringed at intervals of twenty minutes if necessary until it is clear that no blood is accumulating within the bladder. Subsequently, bladder lavage is carried out twice in twenty-four hours. The perineum is dressed frequently if there is any leakage of urine, and packed with cellulose. The tube is removed on the fourth day, and the catheter on the twelfth day. Micturition should then be established and without any urine leaking through the wound.

Modifications.—The skin-incision described is one employed by R. Übethör. It is curved in the reverse direction from that used by Young and most other operators. It has the advantage that the vascular region around the anal orifice is avoided.

Wildbolz* removes the prostate by Young's method and then inserts four sutures which unite the vesical mucosa at the internal urinary meatus to the urethra around the catheter.

Difficulties and complications. **Approach to the prostate.**—This is difficult in patients who have fat buttocks and in whom the anus is deeply placed. The rectum is sometimes so adherent to the posterior aspect of the prostate that only the lowest part can be exposed. In such cases it may be necessary to make an opening into the urethra at the apex of the gland. Through this the tractor is introduced into the bladder and the enucleation performed. Sometimes there is difficulty in introducing the tractor ; if so, the prostate can usually be brought down into the wound by pressure through the abdominal wall above the pubes, though this may be difficult in fat subjects.

Enucleation.—This may be difficult if the prostate is greatly enlarged or if the intravesical projection is of unusual size. Such cases are better dealt with by suprapubic prostatectomy.

Hæmorrhage.—Arteries are sometimes seen spurting at the vesical neck. They should be picked up with long pressure forceps and tied. If bleeding is severe the prostatic cavity should be packed around the catheter with ribbon gauze. In some cases it is best to remove the catheter and replace it by a straight rubber tube, size 30 Charrière (18 English), provided with a metal ring and eyes for sutures, as described in perineal drainage (Fig. 980, p. 1989). Packing can be inserted round this. The need to keep careful watch on the catheter or tube draining the bladder has already been stressed. If blocking should occur and attempts to clear it fail, removal is necessary ; following this, pressure on the bladder above the pubes may be sufficient to evacuate all the clots through the perineal wound. A short straight tube about ½ in. in diameter should then be introduced through the wound into the bladder to maintain drainage. Such treatment is usually sufficient. Rarely, it may be necessary to take the patient to the operating-theatre, explore the bladder and pack the wound.

Secondary hæmorrhage may occur about the tenth day and can sometimes be treated by replacement of the catheter and bladder irrigation. If it is severe, suprapubic cystostomy may be performed and continuous irrigation established. Rarely, it may be necessary to pack the wound.

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* "Lehrbuch der Urologie" 1934, p. 463.

Sepsis within the bladder is treated by irrigation. If it occurs in the wound the removal of the perineal tube is delayed.

Epididymitis can be avoided by vasotomy (p. 2049). It is stated that a suture placed through the prostatic tissue round the ejaculatory ducts will prevent this complication.

Injury to the rectum is particularly likely when seeking the space between the layers of Denonvillier's fascia. It may also occur early in the operation if the dissection is carried too far back, or at any stage if the exposure is poor owing to incomplete dissection or lack of good illumination and adequate hæmostasis. If the bowel is opened, it must be carefully repaired and the operation abandoned, suprapubic prostatectomy being undertaken at a later date.

Incontinence of urine.—This is sometimes a complication of perineal prostatectomy. It is due to injury to the compressor urethræ or its nerve supply. There will always be a serious risk of it if the operation is performed by those not familiar with the dissection of this region, and it is a very serious complication, as it is exceedingly difficult to cure. In Young's original operation the urethra is opened at the apex of the prostate for the introduction of the tractor. Any error in technique during this procedure is very likely to lead to interference with sphincter control. The operation here described includes the modification, which has been widely adopted, of cutting through the prostate itself in order to open the urethra, thus avoiding this complication.

Sexual function.—Young's incisions into the capsule for the enucleation of the prostate are planned to spare the verumontanum and the ejaculatory ducts, but this precaution seems unnecessary for the reasons given on p. 2046.

Mortality of perineal prostatectomy.—H. H. Young* records, in 3,500 cases, a mortality of 3.5 per cent.

PERURETHRAL PROSTATECTOMY

The names of Caulk, Kenneth Walker, McCarthy, Braasch and Bumpus are associated with the development of this operation, which in its modern form was first evolved by Young. Within the last decade it has come to be widely employed in one form or another, so much so that some consider they have in it a quick and safe method of treatment for all cases of enlargement of the prostate. This, indeed, has proved to be the case in the hands of some experts ; nevertheless, the general inclination at the present time is to limit it to certain types of prostatic obstruction. By some it is considered to be a relatively trivial procedure and perhaps on that account it has been recommended for minor degrees of prostatism. It must, however, be remembered that the general indications for the treatment of prostatic obstruction by a transurethral method are the same as those for prostatectomy (p. 2047). If these are not closely adhered to, there may well be a tendency to employ this treatment in anticipation of progressive obstruction ; this is a factor which is extremely difficult to assess. It is undoubtedly in the best interests of the patient rather to keep watch for its appearance than to assume it to be inevitable. It has been stated (Caulk) that after diathermy resection for benign enlargement of the prostate the remainder of the gland tends to shrink, but this is not certain. Perurethral prostatectomy is a measure which relieves obstruction in proportion to the completeness with which it is performed. It must constantly be borne in mind that the aim of treatment in this disease is to relieve mechanical obstruction. If the prostate is much enlarged a great deal of tissue has to be removed. It is not sufficient merely to resect the intravesical projection. If no more than this is done, retention of urine, if present beforehand, often remains unrelieved, while in other instances the volume of residual urine is not appreciably reduced. In a proportion of cases treated to this limited extent considerable reduction of the residuum does occur, and it may be accepted that this is in part due to actual relief of obstruction, but two other factors have to be considered. One is the period of catheter drainage which is the routine after treatment in such cases, and which allows the bladder musculature temporarily to recover its tone. The other is cystitis, which of itself tends to effect a reduction of residual urine (*see* p. 2048). No form of prostatectomy can be considered successful unless the volume of residual urine is permanently reduced to a minimum.

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* "Cabot's Modern Urology," 1936, i, 756.

The views of McCarthy do not entirely accord with the foregoing remarks. He writes :* " the objective being the restoration of the normal cannular character of the prostatic urethra in exaggerated degree. This was the concept of the writer at the inception of this work and it remains unchanged. A number of highly qualified urologists, however, entertain the conviction that what amounts to subtotal prostatectomy is or should be the desired objective."

When a prostate of large dimensions is to be treated by resection the surgeon must anticipate a prolonged operation, and it is often unwise to attempt the removal of all obstructing tissue at one session, for much has to be removed and a large raw and necrotic surface necessarily results. Hæmorrhage is specially profuse in these cases, and renders the procedure unusually difficult. Special provision for bladder drainage by cystostomy may be required, indeed it may be desirable to establish this some weeks in advance. For these reasons prostates which are greatly increased in size, though they can be successfully resected, are by most surgeons usually treated by other routes.

Moderate degrees of prostatic enlargement may be satisfactorily treated by perurethral resection, although many surgeons continue to prefer enucleation. For relatively small, but highly obstructive enlargements, of which the small fibrous prostate is the commonest, perurethral resection is undoubtedly the method of choice. In such instances this operation is comparatively simple, for the tumour commonly contains a high proportion of fibrous tissue and therefore bleeds little. An effective cure is to be expected, and the convalescence is short. These are the cases in which operation by enucleation is most difficult, for the plane of cleavage is rarely well defined. The operation is also well suited to cases in which there is a localized enlargement of the middle or one lateral lobe, forming a ball-valve obstruction.

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* *Bull N.Y. Acad. Med.*, Sept., 1938, xiv, 554.

Preliminary investigations.—Attention should be specially directed towards ascertaining the dimensions of the gland. On rectal examination the projection backwards and added width of the prostate indicate its lateral bulk. The increased height give a measure of its upward extent. This is most accurately estimated by bimanual examination, which is easy unless the patient is unduly obese or quite unable to relax the abdominal wall. Cystoscopy determines the degree of intravesical projection, and if a marked anterior "V" notch is seen at the internal meatus, the resection will be incomplete unless the front portion of the gland is included. It will also reveal the presence of complications such as vesical calculi, growths, or diverticula. Posterior urethroscopy is of special value, as by this means the increased length of the prostatic urethra is recognized, as is the exact distance between the verumontanum and the internal meatus. This is the most important measure of the size of the intravesical projection. A panendoscope (Fig. 1015) is one of the best instruments with which to make this examination, because the view through it is the same as that obtained with the resectoscope ; thus, the amount of tissue which will require removal can be estimated with accuracy. (*See* p. 2083.)

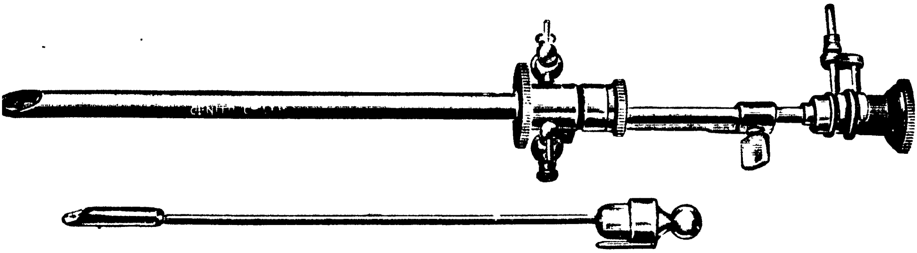

Fig. 1015.—McCarthy's panendoscope.

The urethra must not only be free from stricture, but must be one which can be readily dilated without injury to its mucous membrane to size 26 or 28 Charrière (15 or 17 English) or even larger according to the size of resectoscope to be employed. If the only narrowness in it is at the external meatus, this can be treated by incision, but no attempt should be made to pass a resectoscope through a urethra which, in its other parts, is not sufficiently wide, because of serious danger both of immediate sepsis and ultimate stricture-formation.

Urinary infection, if of mild degree, is not a contra-indication to this method of treatment, but if severe it must be reduced before resection. Renal function must be carefully investigated and the need for treatment to improve this is precisely the same as when prostatectomy by other methods is intended.

Perurethral prostatectomy is often advised for old patients who are in poor general condition. It should not, however, be considered devoid of risk. Certain conditions which may be associated with enlargement of the prostate must be mentioned, together with their treatment, in relation to perurethral prostatectomy :—

Vesical calculi, if small, can be aspirated through the resectoscope, but if large they should be removed by lithotomy ; in such instances suprapubic prostatectomy is likely to be employed, though perurethral resection can be undertaken later if desired.

Vesical papillomata should be entirely destroyed by diathermy before prostatic resection. In malignant growth of the bladder, treatment will be directed rather towards this than to the prostate.

A **vesical diverticulum,** unless it be a small one and holding very little concealed residual urine, constitutes a contra-indication to resection for the reasons given on p. 2024.

Preliminaries.—*Vasotomy,* with the object of preventing epididymitis, is recommended by some surgeons for every patient who is to undergo resection ; it is probably always wise to employ it if sepsis is present.

Cystostomy is used in conjunction with perurethral resection under the following conditions :

(*a*) To improve renal function when catheter drainage is ineffective.
(*b*) In the treatment of cystitis before operation, if this does not readily respond to catheter drainage.
(*c*) If severe infection follows the resection.
(*d*) When an unusual amount of hæmorrhage occurs during the procedure, and persists in spite of attempts to arrest it.
(*e*) To encourage shrinkage of large prostates before resection.

When perurethral prostatectomy has been selected, the necessity for preliminary cystostomy should not be regarded as a reason for abandoning the method, for the operation makes it easier to control either hæmorrhage or sepsis, and continuous bladder-irrigation may help greatly in their treatment. Cystostomy, for this purpose, should be performed immediately above the symphysis pubis by one of the methods described on p. 1980. A suprapubic tube of the de Pezzer type should be used. At the time of the perurethral resection this should be left plugged, though when necessary the spigot can be removed ; a useful means of thoroughly flushing the bladder is thus available.

Perurethral prostatectomy with the McCarthy diathermy resectoscope.—The operation is never easy, and may be one of exceptional difficulty. Experience in the method is essential if the best results are to be obtained. In preliminary training much can be learned by studying the posterior urethra, both in normal cases and in disease, through a posterior urethroscope. Moreover, a preliminary examination with this type of instrument will familiarize the operator with the landmarks in any particular case, and will obviate a search which may be fruitless when the medium has become bloodstained during resection. The fore-oblique telescope which is used in the panendoscope, and also in the resectoscope, is specially designed for the examination of the verumontanum and structures above it up to the bladder-neck. The line of sight is inclined only 15° from the long axis of the telescope, and for this reason the view obtained is very different from that seen through a cysto-urethroscope. The latter, being primarily intended for use within the bladder, has its line of sight at right angles to the shaft of the instrument, or only very slightly inclined from this. The use of the panendoscope is not, however, limited to the posterior urethra, for through it the internal meatus, the trigone, the ureteric orifices, the inter-ureteric bar, and the adjacent parts can be seen perfectly, though considerable practice is necessary before the operator becomes familiar with the appearances of this region through the fore-oblique telescope. This knowledge is all-important for the success of perurethral prostatectomy. There are two important landmarks, the identity of which must be established with certainty, and never lost. These are the verumontanum and the internal urinary meatus.

The **verumontanum** is important because that part of the prostate which forms an obstruction to urinary outflow always lies above it. Neither in resection nor in prostatectomy by other methods is it necessary to remove any portion of the gland below this level. Also immediately above the verumontanum in the middle line the prostate is thin, and if during the process of resection tissue is removed from this region, there is serious risk of opening up the cellular spaces behind it. Furthermore, if the verumontanum is accidentally destroyed, the operator may find that owing to loss of this landmark he is cutting too far down the urethra and thereby risking injury to the compressor muscle. If this is seriously damaged, incontinence of urine may result. Whatever type of resectoscope is employed, the operator will be well advised to glance frequently at the verumontanum. He will thus ensure that if by chance it is partially coagulated at the end of one cut, it will not, owing to a mistake in its identity, be resected subsequently.

The **internal urinary meatus** may undergo various degrees of distortion in prostatic enlargement. The operator should, therefore, study it closely in all aspects before resection is commenced. If the degree of hypertrophy is slight, the inter-ureteric bar may be visible in the same field as the intravesical prostatic projection, although when the latter is more developed the bladder-base is completely screened by it. Those who are inexperienced in the use of the fore-oblique telescope may find difficulty in distinguishing between these two important landmarks, the view being much fore-shortened, so that the inter-ureteric bar appears much closer to the internal meatus than when seen through the right-angled telescope of the ordinary cystoscope. On this account serious errors have been made, and when the inter-ureteric bar has been mistaken for the intravesical projection, cuts have been made with the diathermy loop which have penetrated through the bladder-wall. If in doubt as to these landmarks, the operator can be sure that he is viewing the internal urinary meatus by noticing that if the instrument is withdrawn a little the only view obtainable will be of the posterior urethra, and if the water inflow is shut off, even this is lost, for the walls of the passage collapse upon the objective. On advancing the instrument again by the same amount, the margin of the internal meatus once more comes into view. By rotating the instrument this can be traced round until the anterior 'V' notch, which is characteristic of intravesical prostatic enlargement, comes into view. This is found at 12 o'clock, in cystoscopic terms, or slightly to one side of it. The instrument is now again rotated, keeping the margin of the internal urinary meatus in view, until 6 o'clock is reached. If now the instrument is pushed slightly into the bladder, and the ocular end is raised, the inter-ureteric bar will in many instances come into view and, once identified in this manner, it should not again be confused with the prostatic margin. The operator must not lose his bearings in relationship to either the vesical neck or the verumontanum, and if at any time during the process of resection he is in doubt, he should make a careful check. It is sound practice to complete the resection of one side of the prostate before treating the opposite side ; thus the identity of an important landmark is preserved as long as possible.

Until, therefore, the surgeon feels certain that he possesses an intimate knowledge of the appearances of this part of the urinary tract as seen through a fore-oblique telescope, and, moreover, that he can use correctly the water irrigation which forms such an important part of the system, he will be well advised not to undertake perurethral prostatectomy. For his first attempts he should choose cases in which only a few cuts are necessary for cure, and where hæmorrhage may be expected to be slight.

The **resectoscope** is a somewhat complicated instrument. It is essential to know precisely how to assemble and sterilize it, and to be so familiar with its working that the necessary movements can be performed almost automatically. The diathermy machine must be of reliable manufacture, and if necessary its cutting power should be tested by using one of the resectoscope loops on a piece of meat under water. All connections and switches must be in good order. The general arrangement of this apparatus, of the irrigator, and of the patient should be as described for cystoscopic diathermy of bladder growths (*see* p. 2005), except that a cutting current of greater strength is required. Care must be taken to avoid over-distension of the bladder, and the reservoir of the irrigator must not be more than 2 ft. above the patient. The surgeon usually operates standing, provided that the table can be raised to the necessary height.

The resectoscope is entirely dismantled and sterilized by soaking in 1 : 6,000 oxycyanide of mercury solution. After use it should be well washed under a tap, and the metal parts wiped over with spirit to remove all grease before drying, but spirit should not be applied to the varnished parts. A coagulating electrode and a spare loop should be kept at hand, sterilized. Other equipment which may be required during the operation is a set of metal dilators, a bladder syringe, grab forceps to recover pieces left in the bladder, and the bulb of a Bigelow's evacuator, with a fitting to adapt it to the resectoscope sheath. Suitable catheters and perhaps an introducer will be required at the end of the operation.

The **anæsthetic** will vary according to the surgeon's choice. (*See* p. 2046). It must last for at least one hour, or in a few instances up to one hour and a half.

Strict asepsis must be maintained throughout the operation, and in after-care.

Technique.—To ensure that the urethra is adequate in size, metal dilators are passed, sizes 13/15 to 14/16 English if the resectoscope is of size 26 Charrière, or up to 16/18 if it is 28 Charrière. The resectoscope is then introduced, and in doing so every care must be taken not to injure either the anterior or the prostatic urethra. It must, therefore, be well lubricated, one of the water-soluble preparations being employed, since after paraffin it is difficult thoroughly to cleanse the instrument at the conclusion of the operation. After the beak has passed the compressor urethræ, the outer end of the sheath must be fully depressed, often until it is well below the horizontal plane. Unless this is done the beak is apt to penetrate the prostate, an error which may make its introduction impossible, and which produces laceration and bleeding, greatly obscuring the field of view.

The obturator is withdrawn and urine flows out of the bladder. The inflow tube leading from a reservoir, and the outflow tube draining into a bucket, are joined to the sheath. Washing can be done with a syringe or from the irrigator, water being run in while the end of the sheath is closed with a finger, but little time should have to be spent on this, for if the urine is very turbid the case is not suitable for this operation. The loop-carrier, fitted with its telescope, is introduced, the loop being in the fully withdrawn position. The lamp must be at full brilliance. The sterilized diathermy flex is joined to the instrument, and the foot switch placed in a convenient position. The strength having been previously adjusted on the machine, the current is turned on.

Perurethral resection of the prostate is best begun in the middle line posteriorly, that is in the 6 o'clock position. In the description of the usual technique which follows it is assumed that the prostate is only moderately enlarged. The position of the instrument must, in the first instance, be such that the field of view is wholly that of the interior of the bladder, except for a small portion of the intravesical projection seen in the lowest part of it. The loop can now be safely wound out until it is either in position to make a full length cut, or one less than this according to the distance between the verumontanum and internal urinary meatus. The whole instrument is now slightly withdrawn and the ocular end elevated until the loop is seen to disappear from view behind the intravesical projection of the prostate. The ocular end is raised somewhat further, usually until the sheath makes an angle of about 45° above the horizontal plane. While the left hand holds the sheath very steadily, the current is turned on by pressure on the foot-switch. With the right hand the lever is moved with moderate speed to wind the loop back and thus to make the first cut. Just before this is completed the telescope becomes automatically pushed back into such a position that short-circuiting on to it is impossible. At the end of the cut, when the lever has reached the limit of its rotation, the operator switches off the current by releasing the pressure on the foot-switch. It is important to do so promptly to minimize the risk of burning the sheath. The water inflow may then be shut off and the carrier, complete with the telescope and loop, withdrawn from the sheath when, as a rule, the piece of tissue which has been resected comes out with it, or is perhaps washed out with the water as this gushes out. This should be caught in a receiver by an assistant. Many operators only remove the carrier in order to disengage those pieces which become stuck to the loop, allowing those which are free to drop back into the bladder and remain there until the operation is complete. In either case the bladder should be allowed to empty before a further cut is made, in order to avoid the risk of over-distension. The carrier, if it has been removed, is re-introduced and, the telescope having been pushed forward into the observation position, an examination is made of the field of operation, beginning with the verumontanum. As the instrument is pushed forwards towards the bladder, the trough from which the first cut was made is well seen. By contrast with the urethra on either side, it is pale and bloodless, unless one or more vessels are bleeding where they have been cut across. The position of the verumontanum is again determined by withdrawing the instrument, which is then pushed slightly inwards to shield this landmark from destruction, and the loop is wound along the trough which the first cut has made, for this provides a route by which it can be advanced into the bladder without risk of breakage. When the loop is sufficiently far forward, it will be seen to be once more within the bladder. The instrument is slightly rotated, in order to make the next cut to one side of the first, say at 7 o'clock. In this position the loop again becomes lost to view behind the intravesical projection. The ocular end is raised in order that the loop may embed itself in the tissue, and the second cut is made exactly as in the first instance. A third cut may perhaps be made in the same manner and in the same region, that is, close to the middle line. The operator will be well advised, in the majority of cases, not to make many cuts in the region of 6 o'clock, for when the intravesical projection and that part of the gland which lies immediately behind it has been removed from this area there is usually but little prostatic tissue remaining. When sufficient resection of the middle lobe has been carried out, the operator turns his attention to one of the lateral lobes, and the resection on one side should be completed before beginning on the other. Towards the end of the operation the region of the middle lobe, or any other area, can be trimmed up if necessary ; it is always safer to adopt this course than to cut one part too extensively in the first instance.

It is immaterial which side of the prostate is first resected. It is my practice to deal first with the right lobe. It is well to state again that in the type of case at present being discussed, enlargement of the prostate is assumed to be of only moderate degree. The procedure in dealing with the lateral lobes is that already described. The verumontanum being examined from time to time as a landmark, the sheath is always advanced sufficiently to screen it, and the loop is then wound forward through the trough made by the preceding cuts to a distance sufficient for it to enter the bladder. The sheath is then rotated until the loop comes to lie behind the remaining part of the intravesical projection of the prostate, for which purpose some adjustment may be necessary by winding it in or out but not by withdrawing the sheath. The ocular end of the instrument having been elevated, the foot-switch is used to turn on the current, and the cut is made. This process is continued, working gradually round the clock. Resection of that half of the prostate which is being treated must not be considered complete until the anterior 'V' notch is reached, for although in minor degrees of enlargement, with small amounts of residual urine, less than this may be satisfactory, cases with considerable urinary obstruction will not be relieved if the anterior part of the prostate is untreated. Resection anterior to the line 9 o'clock to 3 o'clock is less easy than in the lower half of the circle formed by the internal meatus, for a view is not so easily obtained and the grip upon the lever of the instrument has to be reversed.

When resection of the right half of the prostate is completed the left is dealt with in a similar manner and to the same extent. It is convenient to lay the pieces out upon a strip of gauze in a position corresponding with that part of the prostate to which they belong. This helps the operator to appreciate how the resection is proceeding.

Hæmorrhage.—In the great majority of cases hæmorrhage is sufficiently profuse to require treatment, and may be very severe ; in a few instances, however, it is so slight that the resection can be completed without the need to give special attention to any individual vessel. Riches reduces the incidence of primary hæmorrhage by injecting into the substances of the prostate a mixture of 0.5 c.c. of adrenalin (1 : 1,000), added to 9 c.c. of percaine (1 : 1,000). For this purpose a special long needle is required, having a bayonet socket at the outer end. By means of a small syringe the mixture is injected under vision into the areas to be resected; the tissues blanch and bleeding is considerably lessened. However, even if this procedure is employed a resection can but rarely be completed without some time being spent in the arrest of bleeding. Another means which has been suggested to limit primary hæmorrhage is to begin the resection with deep cuts at 5 and 7 o'clock, because the main arterial supply of the gland tends to be concentrated at these points, and when the vessels here have been sealed, bleeding during the remainder of the resection is reduced.

It is sound practice to deal with hæmorrhage at the earliest possible moment; whenever, therefore, the making of a cut divides a vessel which is of sufficient importance to spurt continuously, and thereby to impair visibility, it should be at once sealed off, unless it is the operator's intention to make another cut in the same region which must inevitably open up the same vessel. Delay in doing so may cause the medium to become so blood-stained that it becomes very difficult to find the vessel. In treating bleeding of this type the loop should be wound forward until it is brought into light contact with the spurting vessel. If this is done with accuracy a momentary pressure upon the foot-switch will seal it. No attempt should be made to coagulate extensively.

If hæmorrhage is treated in this way a reasonably clear field can be maintained throughout the operation, and at its conclusion less time has to be spent in a search for vessels which have been left unsealed in the hope that bleeding would cease spontaneously. It is sometimes impossible to coagulate larger vessels with the loop, and it then becomes necessary to substitute a small ball electrode. If this is used the intensity of the current should be reduced. To employ this type of electrode the carrier has to be withdrawn to fit it, unless a spare telescope so equipped is available. This is a serious disadvantage, for, by the time it has been re-introduced, there may be considerable difficulty in locating the artery, even though its position had before been accurately determined. This is a further reason for using the loop to deal with each vessel soon after it has been first cut. It may be thought that this entails a loss of time, but the relatively clear field which obtains throughout the resection greatly facilitates each successive step and thereby shortens the total duration of the operation. Moreover the loss of blood is greatly reduced.

The description of perurethral resection which has so far been given is the standard procedure used where the gland is only moderately enlarged. When there is more enlargement and the distance from the verumontanum to the internal urinary meatus is considerably increased, the range of movement of the loop is not sufficient to cover this extent in one cut. Resection is therefore begun with full length cuts at the bladder end of the prostatic urethra and, when this area has been dealt with, shorter cuts are made lower down where required.

In perurethral resection the cuts which are made posterior to the line 9 o'clock to 3 o'clock are longer than those in the anterior half of the circle, for the reason that in prostatic enlargement the urethra is more lengthened posteriorly than anteriorly. As has already been mentioned, special care must be exercised in the region of 6 o'clock, particularly below the vesical neck, where the gland tissue is more scanty.

Resection of prostates that are much enlarged.—When there is much lateral-lobe enlargement, prostatectomy by enucleation is by many considered a better operation than perurethral resection, but if the latter is selected the process must be carried out extensively, particularly in the segments 7 o'clock to 10 o'clock, 5 o'clock to 2 o'clock, and throughout the whole distance from the internal urinary meatus to within a centimetre or so of the verumontanum ; nothing less than this will provide certain relief of obstruction. The procedure is not easy, for the deep wide trough which is so quickly produced when there is only a middle-lobe enlargement to be dealt with, does not readily materialize when the lateral lobes are hypertrophied. On the contrary, until a considerable amount of tissue has been removed these parts continue to bulge towards the middle line. When this stage is passed, a further difficulty is encountered if the ordinary type of McCarthy resectoscope is employed, for the more outlying parts of the gland become increasingly inaccessible owing to the beak of the instrument pushing the upper portions of the gland away and thereby rendering the latter part of each cut ineffective. Severe hæmorrhage is frequent in this type of case, and its control is not easy, yet must be effective. A large raw area necessarily results, and if much sepsis occurs may be a serious complication.

When this method is employed in treating gross enlargement of the prostate it may frequently be wise, at the first session, to confine the resection to one half of the gland, completing the operation after an interval of two weeks or more. If cystostomy is performed some weeks in advance, the gland often shrinks, and this makes resection easier. Suprapubic bladder-drainage still further raises the proportion of cases which are suitable for treatment by this method, because it minimizes the effects of sepsis and aids the control of hæmorrhage. The patient who is to undergo perurethral prostatectomy is naturally anxious to avoid an operation for temporary drainage of the bladder, but permission to perform it, if necessary, should always be obtained.

In all cases, when sufficient tissue has been resected the operator must be satisfied that the control of hæmorrhage is adequate. The water which returns when the bladder is irrigated should not contain more blood than will make it faintly pink. If it is heavily coloured there is a serious risk of clot-retention. In such cases a further search must be made for bleeding vessels, which, when found, should be sealed by coagulation.

Before the resectoscope is withdrawn, any pieces of tissue which have been left within the bladder must be recovered. This can most easily be effected by means of the bulb of a Bigelow's evacuator, filled with water and attached by an adaptor to the resectoscope, gentle compression and suction being employed to aspirate the resected pieces. Other methods are the use of Loughnane's hook (Fig. 1016), or grab-forceps working through an adaptor carrying the telescope ; in either instance the pieces are secured under vision.

The operation is concluded by the introduction of a resection catheter size 24 or 26 Charrière (14/15 English). (Fig. 1017.) This can be passed through the resectoscope before the latter is withdrawn. If preferred, a No. 24 Coudé (14 English) silk-web catheter can be employed, a stylet, if necessary, being used for its introduction. In either case the instrument is fastened in position and syringed through before the patient is returned to bed.

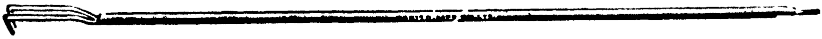

Fig. 1016.—Loughnane's hook.

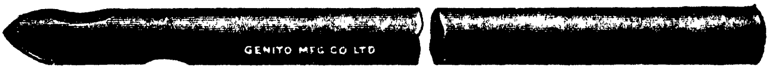

Fig. 1017.—Flute-tipped resection catheter.

A record of the number of pieces removed should be kept and the total mass weighed. Sections of the tissue should be made for microscopy, for coagulation does not prevent a histological diagnosis between malignant and innocent disease.

I use a **modified technique of diathermy perurethral resection.** Except when dealing with a very pronounced intravesical projection, the loop is not advanced so that it enters the bladder to lie behind the intravesical projection. It is placed under vision in position against the prostate, either just below the summit of the intravesical projection or within the urethra immediately below the internal urinary meatus. As the current is switched on, the first movement made is to embed the loop deeply in the tissues by pressure with the beak of the instrument. When this has been done the cut is made in the usual manner. The resection is continued throughout all aspects of the gland, most tissue being resected from the lateral lobes between 7 o'clock and 10 o'clock on the left and between 5 o'clock and 2 o'clock on the right. Care is taken not to remove too much tissue at either 6 o'clock or 12 o'clock, though resection is not omitted in either of these regions.

When the resection has been completed, it is found that a cavity has been excavated from beneath the bladder and, except perhaps in the region close to 6 o'clock, this has been done entirely within the confines of the prostate. The result resembles that which is produced after a prostate has been enucleated. The trigone usually remains untouched, though in the middle line and just on either side a small amount of it may sometimes have to be removed in the process of cutting away the enlargement of the middle lobe from beneath it. If the resectoscope is now withdrawn so that the objective is just above the level of the verumontanum the cavity can be seen, and in the distance is a relatively small opening into the bladder. This presents a marked contrast to the wide funnel-shaped appearance which results from perurethral resection by the usual technique. The opening can easily be enlarged if necessary, but the less of the trigone resected the better from the point of view of immediate hæmorrhage and subsequent sepsis, both of which are diminished by this technique. My modification of the McCarthy resectoscope (Fig. 1018) greatly facilitates the process of excavation of the lateral lobes from beneath the bladder, and with this object it is designed to cause the loop to project well in front of the sheath when in the forward position. This has the added advantage that the loop is much more easily seen than in other patterns of this instrument. The beak is very short but supports the loop firmly in all positions ; thus it is effective for either long or short cuts. It is 26 Charrière (15 English) in size.

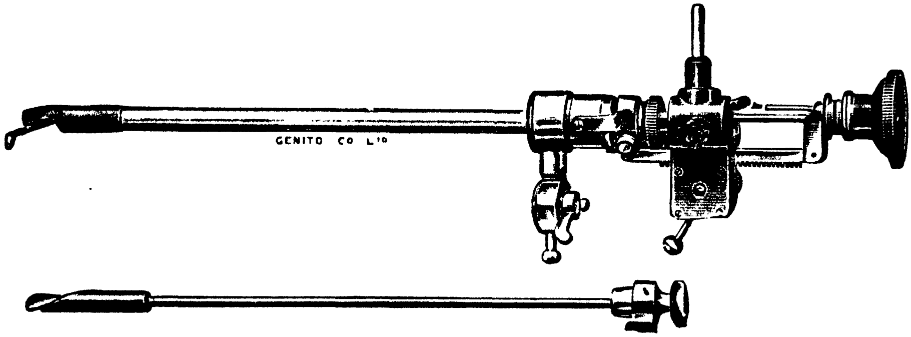

Fig. 1018.—**R. Ogier Ward's modification of the McCarthy resectoscope.**

Most of the pieces are deliberately left in the bladder and removed subsequently by the bulb of a Bigelow's evacuator, or sometimes by grab forceps. A large catheter cannot be introduced through this sheath, but there is no difficulty in introducing it afterwards if a rubber H. Harris catheter with a stylet, or a silk web catheter, is employed.

After-treatment.—For the first twenty-four hours after perurethral prostatectomy it is essential that a very careful watch should be maintained to ensure that drainage is continuous. If hæmostasis has been effective and the catheter is in good position there should be no difficulty. The operation is usually performed under low spinal anæsthesia and the patient is therefore able to resume abundant drinking as soon as he leaves the operating table, thus tending to dilute any blood which may be present in the bladder. The nurse must satisfy herself that the catheter drains continuously. If in doubt, a clean vessel should be placed in position, and if after ten minutes no urine has run into it, it is obvious that the catheter is either blocked or out of position, and steps must be taken to remedy this. If the fault is one of position, gentle pushing of the catheter into the bladder will probably produce a gush of blood-tinged fluid. If it is due to clot, prompt syringing may re-establish drainage. Small quantities should be used, not more than, say, 2 oz. at a time, but these should be vigorously injected with a good syringe in order to clear the catheter from clot. The nurse may safely inject such quantities up to a total of about 10 oz. unless the patient complains of discomfort. If such measures fail to clear the catheter, the surgeon must be informed, and it is for him to decide the next step in treatment.

In some cases there will be reason to anticipate that clots will obstruct the catheter, and it should therefore be syringed with small volumes of oxycyanide of mercury 1 : 6000 every twenty minutes, and later at gradually increasing intervals, until it is clear that the danger of primary or reactionary hæmorrhage has passed. During the succeeding days the catheter should be irrigated about four times in the twenty-four hours to minimize sepsis.

The removal of the catheter.—This step may be taken as early as twenty-four hours after the resection, or may be delayed for a week, according to the persistence of hæmorrhage, the amount of infection present, and the completeness of the resection. The patient may then be allowed to get up. The catheter should be removed at a time when it is convenient for the operator to examine the patient a few hours later, to satisfy himself that the bladder is not becoming distended, for this may happen in spite of the patient reporting frequent and, as far as he can judge, adequate micturition. If partial or complete retention develops, the catheter should be replaced and tied in position. It should not necessarily be assumed that the operation has been a failure, for in many instances after a few days, when healing is more advanced, the patient finds himself able to micturate more freely and the amount of residual urine becomes much reduced. So long, however, as this exists in any considerable volume, treatment by an in-dwelling catheter or by daily instrumentation must be provided. In the absence of drainage the urine becomes increasingly septic and the patient's condition steadily deteriorates.

The patient should not be dismissed from observation until :—

(1) Residual urine is absent or has been reduced to a small amount, and it seems clear that no increase in this volume is likely to occur.

(2) It is apparent that urinary sepsis is not severe, or if present, that it is well tolerated.

(3) The risk of secondary hæmorrhage is past.

If, therefore, the resection has been extensive the patient should be kept in hospital until after the 12th day.

Throughout this period and for some weeks afterwards an intensive diuresis must be maintained. Patients are very apt to relax this as soon as they return to their homes, and in such instances sepsis will often become much increased. Urinary antiseptics should be prescribed, including sulphanilamide or other drugs of this group. Abdominal examination should be made from time to time to ensure that an insidious over-distension of the bladder has not developed, and within a month of the operation a catheter should be passed to determine the volume of residual urine.

Difficulties and complications. (1) *Destruction of landmarks.*—The verumontanum will be coagulated or resected if care is not taken always to end each cut above it. Whenever it has been inspected the sheath must be again advanced sufficiently to cover it. If this landmark is inadvertently destroyed, great care is necessary to avoid cutting through the mucosa in the region of the compressor urethræ and thus injuring the muscle beneath. It may be difficult to be sure where the membranous urethra begins in such a case and, if the operation is continued, only short cuts should be made, and these confined to the upper portion of the prostate. If the technique described is followed and resection of one lobe is completed before the other side is treated, the internal urinary meatus will in part remain intact until the latest stages. With increasing experience the operator will rarely be in doubt of his bearings in this region.

(2) *Hæmorrhage.*—(*a*) Hæmorrhage occurring during the operation should never be allowed to become so severe as to obscure its origin. The importance of dealing with spurting vessels at an early stage, even though they may sometimes be difficult to locate, has already been stressed. If for any reason the hæmorrhage has been considerable, the first step is rapidly to empty the bladder of clot, and for this purpose irrigation with a bladder syringe is most effective. As soon as this has been done the carrier, preferably fitted with a ball electrode in place of the loop, is re-introduced. A systematic search is begun and carried out as quickly as possible. Water is run in fast enough to gain a clear medium, and the instrument moved slowly backwards and forwards to examine the whole area which has been resected. When a blood vessel is met the inflow should be reduced or momentarily shut off, for if left at full strength the blood is washed away so fast that the source and intensity of bleeding is difficult to estimate. As soon as the inflow is closed the bleeding vessel again becomes obvious, and, if large, the blood from it will quickly obscure the view. The inflow tap is therefore partly opened to clear the field sufficiently and yet leave obvious the point which is bleeding. As soon as a good view has been obtained, the electrode is wound forward by means of the lever until the ball at the end of it makes contact with the vessel, then the current is switched on for a moment and the point is usually effectively sealed. Excessive coagulation should be avoided, as it leads to undue necrosis of tissue. Occasionally the bleeding may be so severe that the source cannot be ascertained. In such cases the operator has to decide how much time may reasonably

be devoted to the attempt. If in doubt he will be well advised promptly to adopt some other measure.

Venous bleeding is not usually of great importance, but if a vein of considerable size is opened the arrest of hæmorrhage may be less easy than from an artery, for whereas arterial blood can be seen to issue from a minute and sharply defined puncture, that of a vein comes from a larger opening and one which tends to retract into the tissues. The sealing by coagulation of such a vessel is, for these reasons, often difficult, particularly when, as sometimes happens, even slight pressure near to it with the electrode momentarily stops the bleeding.

Special hæmostatic catheters may be employed, and may be either a Foley pattern size 24 or 26 Charrière (14/15 English), which is made of rubber (Fig. 1019,A) or the Yates-Bell type, which is of silk web construction (Fig. 1019,B). In either instrument a balloon is included near the eyes of the catheter. The catheter is passed until the dilatable portion lies within the bladder. The latter is then inflated by a record syringe through the small tap fitted to the side tube and, when it is sufficiently blown up, the catheter is lightly pulled upon to bring this portion into close contact with the area of resection. While it is held in this position an attempt is made to clear the bladder cavity of clot by syringing through the channel of the catheter. It may be possible by this means, and particularly if the bag is manipulated into the best position, to control the hæmorrhage and at the same time to allow catheter drainage. If this is successfully accomplished the catheter is fixed in position and the rubber portion can be deflated after about four hours. The instrument should, however, be left *in situ* for one or two days.

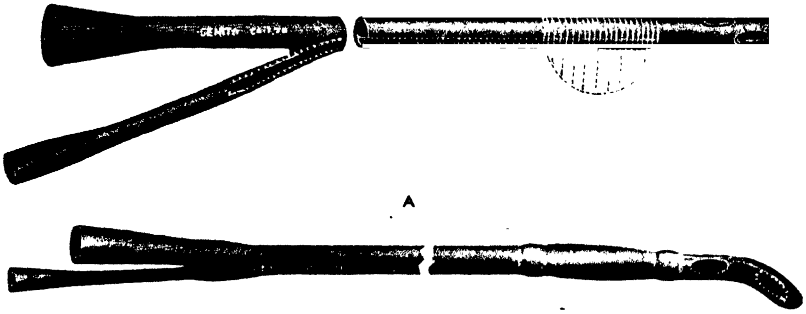

Fig. 1019.—A, Foley's catheter ; B, Yates-Bell's catheter.

If such a special catheter is not available, or if blood clot has already accumulated within the bladder, cystotomy should be performed immediately, and a hæmostatic bag placed in position according to the method used in suprapubic prostatectomy (see p. 2058). If a hæmostatic bag is not available, packing may be introduced into the area resected and kept in position by further packing within the bladder. General measures to combat the effect of hæmorrhage should then follow.

(*b*) *Reactionary hæmorrhage and clot retention.*—It has already been emphasized that no patient should be allowed to leave the operating table until adequate hæmostasis has been effected and all clot has been washed out of the bladder. The need for constant observation of every case of perurethral prostatectomy during the hours immediately following the operation has been pointed out. In some cases, however, in spite of all precautions, blood clot will accumulate in the bladder owing to persistent oozing, or reactionary hæmorrhage may bring about the same result. In such conditions the catheter does not drain freely, lotion injected with a syringe is not recovered, and the bladder presently forms a palpable tumour above the symphysis pubis. If the patient's condition is otherwise good, the treatment suggested by Sampson Handley may be employed. One ounce of glycerin of pepsin is injected through the catheter into the bladder and the end is closed by a spigot. Morphia gr. ¼ is then administered hypodermically. After half an hour the spigot is removed and in many instances the digested clot, together with urine and lotion, will pour out of the catheter. If necessary, a glass bladder syringe can be attached to the catheter and suction employed to remove the remainder. The bladder is then washed out and in many cases, now that it is empty, no further serious hæmorrhage occurs. An alternative method is to introduce the resectoscope and through this to remove portions of the clot with long crocodile forceps, and then gently to wash out the bladder by means of the bulb of a Bigelow's evacuator through the resectoscope.

If, however, such measures fail to empty the bladder, or if hæmorrhage persists, cystostomy should be performed to empty the bladder of clot and to establish drainage, and if necessary, a hæmostatic bag may be introduced.

(*c*) *Secondary hæmorrhage* may occur at any time until the separation of sloughs is complete, but is most likely between the 6th and 12th days. For this reason the patient should be kept under observation until this period is passed. Such hæmorrhage is likely to be complicated by residual urine ; a catheter should therefore be passed and tied in position, and the bladder irrigated frequently. If this is not successful, cystostomy should be performed without delay.

(3) *Sepsis.*—Some amount of sepsis in the area of resection may occur as a result of the diathermy or any other method, but is not necessarily important and it is considerably lessened if my technique is adopted. Regular irrigations will in most cases prevent the development of serious cystitis and ascending infection. Sulphanilamide, or one of the derivatives, is useful. If one or more large diverticula are present, cystitis is likely to be very severe ; the method should not therefore usually be employed in such cases.

(4) *The loop fails to cut.*—It may happen that, when the lever of the resectoscope is wound back and a cut is concluded, no piece of tissue

is withdrawn. This may be because the piece has been left in the sheath or lost within the bladder. An examination of the area just treated will usually differentiate between the temporary loss of a piece which has been resected, or an imperfect cut, for in the latter case the piece of tissue may be seen to be only partially detached, and if so the loop must be again engaged and the cut completed to effect its removal. If, however,.it is apparent that when the loop is moved no cutting is taking place, the operator must ascertain whether this is due to an error in technique, such as failing to embed the loop properly by adequate lifting of the ocular end, or to some fault in the equipment. If the latter is suspected, the loop should be examined, and if it has become flattened out it should be gently bent back into position. If this does not rectify matters, the flex leading from the instrument to the resectoscope should be carefully examined for, as a result of frequent boiling, the wires within this may have disintegrated either in part or completely, for which reason a spare lead should always be available. If the loop is tested on a piece of meat under water before the operation, such failures will be avoided. The diathermy machine itself, if of first class manufacture, is most unlikely to fail. The foot-switch or flex leading to it occasionally is at fault.

(5) *The water does not return through the sheath when the carrier is removed.* This may be due to blocking of the lumen of the resectoscope by a portion of resected tissue, or to a mass blood-clot within the bladder in contact with the beak of the instrument. A bladder syringe should be used, a few ounces being vigorously injected. If this measure is unsuccessful, the surgeon should palpate the abdomen through a sterile towel laid upon it. If the bladder can be felt to be distended a further endeavour by syringing should be made to empty it, but if it is not palpable the failure of water to return may be due to a cut having penetrated through the prostatic capsule. This is particularly likely to happen if too much tissue is resected in either the 6 o'clock or the 12 o'clock region. Only gross errors of technique will lead to perforation of the trigone, which would, of course, produce the same result. Since in such a case it will be difficult to determine the site of leakage, it is best at once to perform suprapubic cystostomy and provide drainage of the prevesical space. Inexperience has led to even more serious injuries, and cases have been reported in which the rectum has been opened.

(6) *Epididymitis* is not more likely to follow this operation than any other in which a tied-in catheter is required. Preliminary vasotomy to avoid it has already been described (p. 2049).

(7) *Stricture formation* is less likely if the modern metal-covered resectoscope sheath is employed, as this is more easily introduced than the original patterns, which were made of bakelite. It is always a possible complication if instruments of 28 Charrière and larger sizes are employed. Any undue narrowing of the urethra should be considered a contra-indication to perurethral prostatectomy, and the

method should be abandoned if difficulty is encountered in the introduction of dilators or the resectoscope. Cabot has suggested that the resectoscope should be introduced through an external urethrotomy incision made into the bulbous urethra, thus avoiding injury to those parts which are particularly susceptible, namely the external meatus, the fossa navicularis, and the anterior portion of the penile urethra. If strictures form they are likely to be severe.

A more immediate danger resulting from urethral injury is that, during the period of catheter drainage, septic absorption takes place through areas where the mucosa has been lacerated, causing serious catheter fever.

(8) *Uræmia.* Assuming that due care has been taken in estimating renal function and in emptying the bladder if it has been over-distended, uræmia is unlikely. If it does occur it will be the result of pyelonephritis.

(9) *Failure to relieve the obstruction.* The need for close observation of the amount of residual urine after perurethral prostatectomy has been pointed out. When sufficient time has elapsed to allow the œdema following the operation to subside and sloughs to separate, the need for a further resection is apparent if a considerable volume of residual urine remains. This may also be required if for some reason, such as the large amount of tissue requiring resection, or because of troublesome hæmorrhage, the operation was deliberately left incomplete. A second resection may be undertaken a fortnight after the first, though it is often preferable to wait for three or four weeks and this will certainly be better if a cystostomy has been established. If the renewal of the operation is attempted too soon, sloughs in the posterior urethra will make the procedure difficult and the coincident sepsis increases the risk.

It may be necessary to abandon an operation of perurethral resection before it has been completed, and the surgeon may feel unwilling to proceed further by this method ; there is no difficulty in subsequent prostatectomy by enucleation.

Results.—McCarthy writes* that " the permanency of results is largely dependent upon the thoroughness of the resection," but he goes on to state that " this need not, however, be carried to the point of subtotal prostatectomy," and he supports the view that " when the obstruction is relieved there is a recession of the residual prostatic tissue." His experience of this method is, of course, a very wide one. I believe, however, that nothing is lost and much is gained in immediate results by the resection of large amounts of tissue from beneath the bladder, and it seems reasonable to suppose that the permanent results of this method will also be satisfactory. But since recurrence of obstruction, due to the growth of an isolated adenoma, is not unknown after prostatectomy by enucleation, it is impossible that perurethral resection in any form should be an absolute guarantee of permanent cure. The McCarthy technique has, however, been under trial for a sufficient time to show that recurrence is uncommon, and the patient who has realised the benefits of the operation would probably be quite willing to face a further treatment of the same kind if necessary. McCarthy adds : " In general, it may be said that resection mortality, in competent hands, will probably vary between 1 and 4 per cent. inclusive, depending on the risks assumed, and in individuals ranging from fifty to ninety or more years."

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* *Bull. N.Y. Acad. Med.*, Sept. 1938, xiv, 563.

Other methods of perurethral prostatectomy.—At the present time the McCarthy type of resectoscope is most widely employed, though there are other varieties of diathermy methods. The only other instrument of importance is the Braasch-Bumpus resectoscope and the modifications of it by Gershom-Thompson. These are derived from the prototype of Young's punch. At the present time cutting is done by a tubular steel knife without preliminary diathermy, this being reserved for dealing with bleeding points. These instruments have no optical system and the operator has to learn to work without one. Resection is done partly by vision and partly by touch, and most operators find it so different from all other instrumental procedures that there is difficulty in learning it. The method has the advantage that sepsis is reduced to a minimum. In the hands of those who specialise in this work excellent results are obtained with these instruments.

PERMANENT CONTRA-INDICATIONS TO PROSTATECTOMY

1. Failure of preliminary treatment to remove certain of the following complications, viz., sepsis, circulatory, pulmonary, or gastro-intestinal complications of severe grade ; and particularly renal insufficiency. If the blood urea does not fall below 75 mg. prostatectomy is accompanied by grave risks, even when clinical improvement has been satisfactory.
2. Increasing general feebleness.
3. Extreme old age. Many extremely old patients have been operated on successfully. Freyer relates that in 1,625 cases of prostatectomy he had operated on 92 men between 80 and 90 years and 18 in their 80th year with 12 deaths (11.5 per cent.). The mortality here is twice that of his total average. In Thomson-Walker's cases there were 27 of 80 years or over, with 3 deaths, a death-rate of 11.11 per cent., which closely corresponds to Freyer's figures. While, therefore, age should not be regarded in itself as a contra-indication to prostatectomy, the feeble resistance and the probable expectation of life of these aged patients must always be borne in mind in considering the best line of treatment. Complications such as sepsis, hæmorrhage and difficulty in catheterization may necessitate operation in aged patients where otherwise it might be avoided.

When the patient is considered unfit for prostatectomy it may be deemed advisable to forego all surgical treatment. In many cases, however, relief of the obstruction must be undertaken and this may take the form of catheter life. The mortality for the first month of this is 8 per cent.[*] The alternative is permanent cystostomy (p. 1988). Some other measures at present under trial are alluded to on p. 2048. Perurethral resections may sometimes be done when all other methods carry too great a risk.

The Treatment of Post-Prostatectomy Obstruction

Treatment may be required for obstruction following prostatectomy with or without persistence of the suprapubic fistula. Thomson-Walker analysed 75 cases of this sequel to suprapubic prostatectomy ; the causes of obstruction were :—

1. Fibrous contraction at the site of operation in 69 cases. In 66 of these the obstruction was situated at the vesical end of the cavity ; in 3 it was at the urethral end. He found that it was particularly likely to follow operation for small fibrous prostates, but occurred in all types of case.
2. Recurrence of simple enlargement of the prostate by development from layers of prostatic tissue remaining in the prostatic bed or from " adenomata " which had not been removed at prostatectomy.
3. Malignant growth in the wall of the prostatic cavity.

Fibrous contraction may follow either suprapubic or perineal prostatectomy, and no form of operation provides certain immunity from this complication. The internal meatus may be completely obliterated ; more usually it is reduced to the size of a small probe. The opening may be displaced, and most frequently this is in a forward direction, but it may lie laterally. A ring of dense fibrous tissue often surrounds it. The condition should be suspected if the patient reports that the urinary flow is no longer as full as when micturition was first re-established, when there is considerable delay in the healing of the suprapubic fistula, or if this re-opens from time to time. It is frequently accompanied by chronic cystitis which, instead of diminishing as the interval after the prostatectomy lengthens, either remains constant or becomes worse. Lack of control of micturition, leading to wetting of the clothes, also calls for investigation of the urethra. Instrumental dilatation is usually effective in treating the less severe degrees of such obstruction ; steel or flexible bougies should be tried, and in some instances those of the Beniqué pattern will enter the bladder when others fail. If dilatation can be effected it should be continued at weekly or longer intervals for about three months, and perhaps on a few subsequent occasions until a year has elapsed. It should be accompanied by bladder irrigation. If the opening is much contracted it will not be possible to pass a bougie into the bladder by ordinary means, and operative treatment is therefore required. This may take the form of :—

Diathermy incision through a posterior urethroscope.—The patient is anæsthetized and placed in the lithotomy position with the indifferent diathermy pad beneath the buttocks. A panendoscope of size 24

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[*] Watson's " Operative Treatment of the Hypertrophied Prostate," *Ann. Surg.*, June, 1904, xxxix, 853.

Charrière (14 English), is introduced until, after the compressor urethræ has been passed, a resistance is encountered before entering the bladder. No attempt is made to pass the instrument farther and every care should be taken to avoid producing hæmorrhage. The pilot is now withdrawn, the telescope introduced, and the water inflow tap opened. By manipulating the instrument and gently advancing it, and particularly by depressing the optic, a view is obtained of the narrow opening into the bladder at the top of the prostatic fossa. The inflow is then shut off until the operator is quite ready to use the diathermy, for a view is only obtainable while the water is running through the cavity, and when once the bladder is filled the flow becomes sluggish. A Collings's diathermy knife (Fig. 1020) is passed through the sheath of the panendoscope and joined to the electric lead. The diathermy is set to a moderate degree of cutting current. When all is ready the inflow tap is re-opened and the blade of the knife pushed forward to enter the opening into the bladder or, if this is not possible, it is brought into contact with its posterior margin. The current is switched on for a moment and the blade of the Collings's knife thus activated is made to cut through the tissues in a posterior direction for about $\frac{1}{8}$ of an inch. This distance may be exceeded, but only when it is seen clearly that the opening into the bladder has been displaced forward and that there is a large overhang of fibrous tissue at the top of the prostatic fossa, for the rectum is in close apposition and may be wounded by excessive cauterization. Other cuts may be made laterally in a similar fashion, and the opening enlarged sufficiently for the panendoscope to enter the bladder. In rare instances it may be necessary to cut away scar tissue by means of a resectoscope. The cuts should be made only on the lateral aspects owing to the serious risks of injuring the rectum. When the bladder has been examined and washed out the instrument is withdrawn and metal dilators are passed and a 24 Charrière (14 English) catheter is tied in. By this method the great majority of post-prostatectomy obstructions can be treated, and, when once fully dilated, this condition can be maintained by instrumental dilatation at increasing intervals for a period of six months. After such treatment the patient may suffer from incontinence, sometimes to a severe degree, but recovery is usually complete and seems to depend on the gradual absorption of the scar tissue surrounding the upper part of the urethra.

Open operation for obstruction is sometimes necessary, and is often the best method if there is a persistent suprapubic fistula which needs excision. The bladder is widely opened and a retractor introduced. In most instances the narrowed outlet into the urethra is seen. If it is not obvious, or if it has been completely obliterated, a steel bougie should be passed through the penile urethra until its point begins to lift up the lower part of the trigone, thus showing the degree of displacement of the opening. This also indicates the extent to which it is necessary to enlarge the opening, if one is present, or where to make a fresh exit if the bladder base is completely closed. Cutting is best done by a long-handled knife with a small blade, and in a backward direction, but should not be carried too deeply, for the rectum lies close beneath this region. It may be necessary to excise a dense mass of scar tissue to obtain an adequate channel. In some instances the internal meatus of the bladder has been drawn so far downwards and forwards that it is out of sight beneath the pubic arch. A steel bougie in the urethra is, however, a guide to its position, and upon the point of this an incision should be made. In all cases full-sized dilators should be passed and a catheter placed in position while the retractor is still *in situ*. If bleeding and sepsis are slight the bladder may be closed by primary suture. In other cases a small suprapubic tube of the de Pezzer type is required for a few days. Open operation will also be employed if calculus formation in the prostatic fossa or in the bladder complicates post-prostatectomy obstruction.

OPERATIONS FOR CANCER OF THE PROSTATE

Various attempts have been made to treat carcinoma of the prostate by radical extirpation, but have not met with success, not only because of the inherent difficulty of taking away a sufficient margin of healthy tissues beyond the confines of the growth, but because it is impossible to remove the associated lymphatic glands and the paths of spread towards them. Radium has been used, but has the grave disadvantage that needling is apt to cause early dissemination with the appearance of secondary deposits in remote parts, thereby hastening the spread of a disease which for a long time is normally confined within the prostatic capsule.* Deep X-ray therapy is under trial, but the results so far have not been satisfactory. Operative treatment is therefore confined to those cases of urinary obstruction in which the catheter gives only temporary relief. Before it is undertaken, the bladder should always be examined by cystoscopy, for if the growth is approaching closely to the ureteric openings the expectation of life is necessarily brief. X-rays should be taken of the pelvis and spine to ascertain if secondary deposits are present in the bones. Such an examination will also show the presence of prostatic calculi, in which case the diagnosis of carcinoma would require further consideration. If bladder drainage is necessary this may be provided either by perurethral resection or by permanent suprapubic cystostomy. The latter operation is suited to all cases and is described on page 1988.

Perurethral resection can be employed with very good results. The operation is usually easier in carcinoma than in benign enlargement as bleeding is less profuse. Narrowing of the prostatic urethra sometimes occurs in carcinoma and may make the introduction of the instrument difficult or even impossible. The risk of causing dissemination of the disease appears to be slight. The resection can be repeated if necessary should the obstruction recur, but is rarely required as the neoplasm grows very slowly. The expectation of life is perhaps not quite so long as after cystostomy, but the patient is spared the inconvenience of wearing a urinal.

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* Hormone therapy sometimes produces marked temporary improvement. Castration has been performed.

In a certain proportion of cases a prostate which is presumed to be the seat of benign enlargement will be enucleated only with great difficulty. This may be due to fibrosis or to the fact that a portion of it is carcinomatous. In the latter case microscopy will reveal areas of carcinoma in a specimen which is otherwise innocent. In such cases a course of deep X-ray therapy may be recommended, although results are far from satisfactory in most cases.

Carcinoma of the prostatic fossa may follow the enucleation of a gland which is already in part affected. This condition also develops in a few instances after operation for benign enlargement of the prostate, usually at a long interval, and will then give rise to a recurrence of prostatic obstruction. In either case the only treatment available is cystostomy if urinary obstruction makes this necessary.

OPERATIONS FOR PROSTATIC ABSCESS

In the majority of cases with prostatic infection the pus is discharged through the ducts or by the bursting of the abscess into the prostatic urethra. Retention of urine can usually be dealt with by catheterisation, but in rare instances cystostomy may be required. Incision of a prostatic abscess is sometimes required. The method adopted may be :—

1. **Perineal prostatotomy.**—The approach to the prostate is that described for perineal prostatectomy (p. 2074). Some surgeons prefer a vertical midline incision in the perineum as this heals more readily. An exposure of the deeper parts, however, is not so easily obtained when this is used. Great care is taken to avoid opening the rectum. Less harm results if the dissection is carried too far forwards, since the sound in the urethra acts as a guide to its position, and though injury to the vascular tissues of the bulb makes the operation more difficult, it is otherwise unimportant. When the recto-urethralis muscle has been divided and the layers of Denonvillier's fascia are being separated, the abscess is often ruptured. If so, it is only necessary to enlarge the opening with a finger and to put a drainage tube in position. The prostate may, however, have to be fully exposed before the site where the abscess is pointing is found. If at this stage there is still doubt of its position, incision should be made into both lobes of the prostate for a depth of about ¾ inch. Sinus forceps should be used to enlarge these openings and to ensure that all septic cavities are laid open. Care must be taken to avoid cutting into the urethra ; in spite of this, however, urine may sometimes be subsequently voided through the perineum. If the fistula does not close spontaneously it will be necessary to tie in a catheter to promote healing.

2. **Trans-rectal prostatotomy.** This method should never be employed if the abscess has already opened into the urethra, on

account of the risk of recto-vesical fistula. The patient is placed in the lithotomy position. The rectal sphincter is dilated and the most prominent point of the abscess identified. This is then incised with a small knife and the opening further enlarged with sinus forceps, or by the finger.

CHRONIC PROSTATITIS

Only in exceptional cases will surgical treatment be employed in this condition, but if the patient is liable to recurrent attacks of acute inflammation of the gland,* and posterior urethroscopy reveals one or more dilated duct from which purulent material exudes, a valuable method of treatment is to lay these open by means of a Collings's knife (Fig. 1020) through a panendoscope. This must be done with caution, but the incision should be adequate to drain the granulation lined cavity with which the duct communicates. A portion of the gland lying between this area and the vesical neck may also be excised. The operator should not attempt to do too much at one session, and should be prepared, if necessary, to repeat the procedure after an interval of some weeks.†

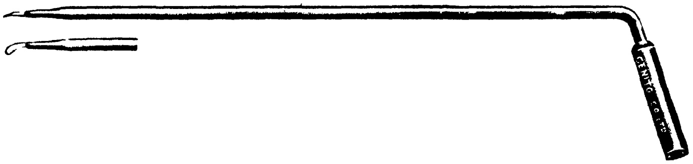

Fig. 1020.—Collings's knife.

PROSTATIC CALCULI

Prostatic calculi of minute size are often associated with benign enlargement of the gland, but are rarely met in carcinoma. They do not require any special treatment, and do not interfere with prostatectomy. Larger calculi occur as the result of chronic prostatitis and may, as they develop, destroy the gland almost entirely. If, in such cases, urinary obstruction is present, this is most likely to be due to urethral stricture. It is rarely advisable to remove the calculi. This can, however, be undertaken by the suprapubic route, when the enucleation of the gland and calculi within it is usually very difficult. It is better effected by perineal prostatotomy. When the posterior aspect of the prostate has been exposed, and incised, a scoop removes the calculi. It is important to ensure that all of them are removed. Prostatic calculi which have formed in the part of the gland adjacent to the urethra can be removed by operation through a panendoscope. Through this, incisions are made with a Collings's knife into the gland, on either side of the verumontanum, of sufficient extent to allow calculi to escape into the urethra. A finger in the rectum may assist.

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* Perhaps with fever and rigors.

† Gershom J. Thompson and Edward N. Cook: Chronic Prostatitis and Prostatic Calculus. Treatment by incision with the electrocautery. *Journ. Amer. Med. Assoc.*, March 9, 1935, civ, 805.

THE SEMINAL VESICLES

Abscess of a seminal vesicle, acute or chronic, rarely requires operation since it usually drains into the urethra under expectant treatment and vesicular massage. It is frequently associated with epididymo-orchitis, and, if this is so severe that orchidectomy becomes necessary, the spontaneous cure of the inflammation of the seminal vesicle may be expected. If, however, it is necessary to open an abscess of one or both vesicles one method of approach is as for perineal prostatectomy (p. 2074). When the upper margin of the prostate is reached the distended vesicle is readily palpated and incised. A drainage tube is placed in position.

The excision of vas deferens and vesicula seminalis through the abdomen is an alternative method. The patient is placed in a modified Trendelenburg position. The incision is commenced at the inguino-scrotal junction just internal to the pubic spine. Its downward extent depends on whether an epididymectomy or orchidectomy is also being performed. The incision extends upwards, an inch above and parallel with Poupart's ligament, to the level of the anterior superior iliac spine, and passes through skin and subcutaneous tissue. Any vessels which are divided are picked up and ligatured. The aponeurosis of the external oblique is incised and the inguinal canal is opened. The internal oblique, transversalis and the transversalis fascia are incised in the same line, i.e., across their fibres. The deep epigastric artery can be seen on the inner side of the vas as the latter hooks round it, and should be preserved. The peritoneum appears in the depths of the wound and is carefully separated from the side wall of the pelvis.

The cord is still lying in the inguinal canal. An incision is made in its sheath at the level of the pubic spine and the vas is carefully dissected from the floor of the canal and from the side wall of the pelvis. Care must be taken to apply only the lightest traction on the vas as it easily tears across and if this happens the operation is much more difficult. The dissection in the pelvis should be done under vision and not with the finger. By careful inward retraction of the peritoneum and vas, the latter can quite easily be dissected off the pelvic wall. It first crosses the external iliac vessels and then, running backwards and downwards, it passes medially to the obliterated hypogastric artery, ureter and obturator vessels and nerve. It is freed down to the vesicle and, on opening the fascia surrounding this, the vascular pedicle can usually be seen ; it is picked up, ligatured and cut. The vesicle now appears, tortuous and greyish white. The peritoneum is separated from its posterior surface and with traction on the fundus with forceps, it is dissected off the posterior wall of the bladder, to which it is loosely attached. With curved scissors, it is cut away at its lower end together with the vas, close to the prostate, and the stump is touched with the cautery or pure carbolic acid. The patient is now placed in the horizontal position. The peritoneum falls against the side wall of the pelvis and the inguinal canal is carefully closed in layers.*

For the treatment of **genital tuberculosis** which requires orchidectomy, Young has described a radical operation in which the affected side of the prostate and the seminal vesicle with it are removed through the perineum. The testicle and the whole of the vas are then removed through the groin. Most surgeons, however, find this operation unnecessary.

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* Baudet and Duval, *Rev. Chir.*, 1901, xxiii, 395.

CHAPTER XLIV

OPERATIONS ON THE URETHRA

By JOHN EVERIDGE

Intra-urethral operations by endoscopic methods.—Examination of, and minor operations upon, the urethra are carried out by means of the urethroscope. The variety of instruments is wide and, since they are used for examination rather than for operative technique, require little more than mention. Several urethroscopes have, however, been adapted to the performance of minor operations on lesions in both the anterior and the posterior urethra.

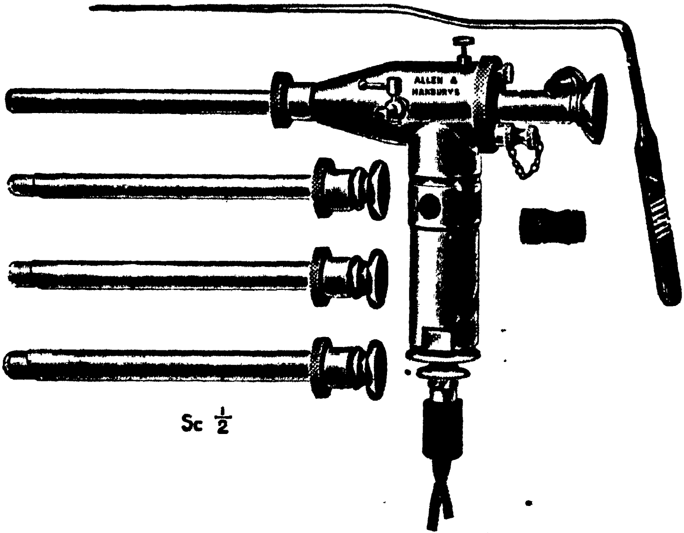

Fig. 1021.—Swift Joly's anterior urethroscope.

The anterior urethra.—The aero-urethroscope (Fig. 1021) designed by J. Swift Joly * provides facilities for visual examination, and its operative attachment simplifies treatment of many of the minor affections to which this section of the urethra is liable. Thus, inflamed follicles and lacunæ can be touched with the silver-nitrate-coated probe or the cautery, the face of narrow or tortuous strictures can be inspected and fine instruments passed, and impacted calculi and foreign bodies grasped with suitable forceps and removed. It must be remembered that incision of abscesses under air-inflation is dangerous from the possible complication of air embolus. The diathermy coagulating current has almost entirely supplanted the knife.

The posterior urethra.—Space does not permit a detailed description of the many complicated instruments available. The majority of posterior urethroscopes employ an irrigation system to facilitate separation and examination of the walls of the urethra. Blood and débris are washed away by the flow and the whole length of the floor of the prostatic urethra may be examined without difficulty. Many of the posterior urethroscopes are adapted for conducting a catheter or electrode, with the aid of which a ruptured prostatic abscess may be irrigated with antiseptics through the opening in the urethral wall or its opening enlarged by the high-frequency cautery to establish better drainage.

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* *Lancet*, Jan. 1914, i, 114.

The diathermy current permits cauterization of papillomata and polypi, electro-coagulation of the hypertrophied verumontanum, and resection of obstructive prostatic projections or fibrous tissue. Some operators have catheterized the ejaculatory ducts and irrigated the seminal vesicles with colloidal silver or other antiseptics in cases of obstinate vesiculitis, but the technique is not, at present, sufficiently developed to be of practical value.

Among the posterior urethroscopes combining the essentials of good visualization with adjustments for performing the operations referred to, three have been found reliable, namely the posterior urethroscope of Buerger,* the cysto-urethroscope of Wolff and the cysto-urethroscope of McCarthy,† now known as the panendoscope (see Fig. 1015, p. 2081). All these derive their source of illumination from a distally placed lamp. In the first two the optical system supplies indirect observation similar to that in use with the Nitze type of cystoscope. The panendoscope is now equipped with a " fore-oblique " telescope which focuses at an oblique (25 degrees) angle thus more nearly corresponding to direct than to indirect observation ; the instrument is therefore suitable for a study of the bladder neck as well as for the trigone and the posterior urethra. Further advantages of this instrument are the very efficient system of irrigation and the ease of passing and precise control of large calibre accessories, coagulating electrodes, the Colling's knife and ureteral dilators, for the bladder base is within easy visual range. The prostatic resectome of McCarthy is an elaboration of the panendoscope (see p. 2084).

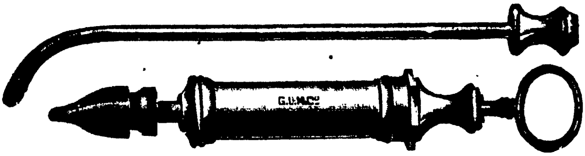

Fig. 1022.—Syringe for urethral anæsthesia (Everidge).
(For additional uses, see p. 2108).

If anæsthesia is required, the syringe shown in Fig. 1022 can be used to introduce fluid first into the anterior urethra. The fluid is then massaged through the compressor urethræ and, after 3 minutes, the posterior urethral tube, which fits the syringe, is passed and

* *Journ. Urol.*, 1911, vii, 327.
† *Journ. Urol.*, 1923, x, 519.

novocaine solution is instilled into the deep urethra. The orifice of the rubber nozzle also fits a ureteric catheter, and so this syringe may be used for washing through such catheters. This syringe may also be used for displacing a clot in a urethral catheter.

REMOVAL OF CALCULI FROM THE URETHRA

A calculus recently impacted in the **anterior** urethra where no stricture is present may be extracted by snares, fine alligator forceps, or some improvised hook made from a probe. If there is difficulty in passing the external meatus, meatotomy is carried out.

Where the calculus has been present in the urethra for some time, it almost invariably lies behind a stricture or in a diverticulum, and a perineal fistula is frequently present also. These calculi must be removed by open incision if dilatation or internal urethrotomy is insufficient to allow the stone to pass naturally or to be extracted.

The perineum is prepared and a staff passed into the urethra. When a large calculus is present the staff will not pass, and if a narrow stricture is present the attempt need not be made.

The patient is placed in the lithotomy position, and an incision is made in the middle line over the calculus, which can be felt from the surface. If a fistula is present, this is dissected down to the urethra, and the urethra opened. The calculus is grasped with small lithotomy forceps and removed without difficulty if it is loose and of moderate size. Sometimes, however, it is adherent to the urethral wall, and the mucous membrane must be peeled off it. If a stricture is present an instrument can now be passed from the external meatus through it, and, using it as a guide, the incision is extended forwards to sever the fibrous ring. If an operation of this nature is carried out in the neighbourhood of the bulb a perineal drainage-tube is passed into the bladder from the posterior end of the perineal wound and retained for a few days.

From the prostate and prostatic urethra.—A calculus may lie in the lumen of the prostatic urethra. In old-standing cases additional deposits may have been added so that it comes to project into the bladder through the vesical sphincter and a mushroom calculus is formed. A calculus may also lie in a pocket communicating with the prostatic urethra ; it projects partly into the lumen of the urethra.

True prostatic calculi are buried in the substance of the gland, and are usually grouped in closed cavities. Prostatic calculi should be removed by the suprapubic route. An exception is made where the calculus is recently impacted in the prostatic urethra, or where it is small and freely movable. In these cases large steel sounds are passed, and the surgeon endeavours to push the calculus back into the bladder. If this is accomplished, either the calculus is removed by means of an aspirating bulb and cannula or, if it is too large to pass the cannula, it is crushed and removed. A small recently-impacted calculus may pass out with the stream of urine after a catheter has been tied in the urethra for one or two days.

When a calculus is too large or is fixed, or when it lies in a pocket or is buried in the substance of the prostate gland, suprapubic removal of the whole gland is the best method, using the endothermy current to dissect the prostate, for digital enucleation is seldom possible. The proximal urethra has a tendency to contraction in these cases and subsequent dilatations, at intervals, may be necessary.

If a mushroom calculus is present, it is removed suprapubically by traction on the vesical portion. If the calculus is contained in the expanded prostatic urethra, the posterior lip of the internal meatus is freely incised in the middle line and the calculus extracted by lithotomy-forceps or scoop (Fig. 1023.)

Fig. 1023.—Lithotomy scoop.

OPERATIONS FOR STRICTURE

The majority of strictures of the urethra are cured or relieved by the regular passage of dilators but in certain cases a cutting operation becomes necessary.

Indications for urethrotomy.—

1. Cases unsuitable for gradual dilatation.
    (1) Impassable stricture, or stricture so narrow that only a filiform bougie will pass.
    (2) Cases complicated by urethral calculus, peri-urethral abscess, urethral fistula, extravasation of urine.
    (3) Certain diseases of the prostate or bladder complicated by stricture, where immediate endoscopic manipulations are necessary. Such are enlarged prostate, stone, tuberculosis, new growths, chronic cystitis.
    (4) Some diseases of the kidneys complicating stricture (pyelitis and pyelonephritis) (see p. 2113).
2. Gradual dilatation has been tried and proved inadequate.
    (1) Dense fibrous stricture.
    (2) Resilient stricture.
    (3) Where stricture is intolerant of dilatation, as shown by the skilled passage of instruments being followed on each occasion by rigors, hæmorrhage, retention of urine, or epididymitis.
    (4) Peri-urethral abscess or extravasation of urine complicating the passage of instruments.
3. The stricture is suitable for dilatation, but the patient is unable or unwilling to carry out the treatment.

INTERNAL URETHROTOMY

The operation consists in cutting through the stricture by a guarded knife (urethrotome) introduced along the urethra. The stricture may be cut from before backwards, that is towards the bladder, or from behind forwards. It may be cut on the roof or on the floor. The usual method is to cut from before backwards on the roof of the canal.

There are many varieties of urethrotome. Thomson-Walker's is a modification of Maisonneuve's. (Fig. 1024.) It consists of a fine curved metal staff which has a deep groove on the concave surface, extending from the proximal end to just beyond the commencement of the curve. At the point of the staff is a male screw on which a small bulbous tip fits. This tip may be removed and a fine flexible guide (4 F.) screwed on to the end of the staff by means of a metal end with a female screw. This metal end is tapered and projects a short distance inside the flexible guide, which thus expands gradually to the thickness of the staff. A triangular knife is fixed at one end of a fine steel rod, the other end of which terminates in a metal button on which is the number representing the size in French gauge to which the knife cuts. The apex of the triangular knife is blunt, smooth, and broad, so that it can glide along the mucous membrane without cutting it. The anterior and posterior edges of the triangle are sharp. A small flange on each side of the base of the triangle runs under the lips of the deep groove in the staff and prevents the knife from slipping up. Two large flat transverse wings are fixed on each side near the proximal end of the staff and provide a good grip for the fingers and thumb of the assistant. A steel rod which fits into the groove in the staff serves to stiffen it during the introduction of the instrument, and is useful in cleaning the groove. The rod is removed for the insertion of the knife.

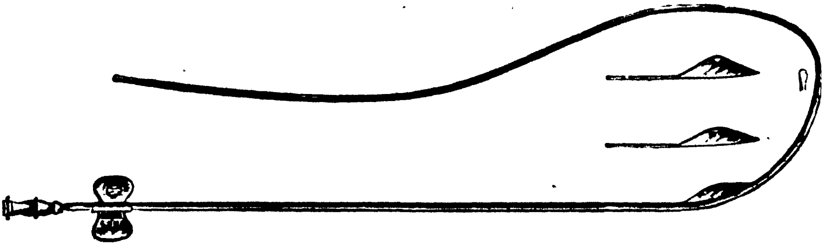

Fig. 1024.—Thomson-Walker's urethrotome.

This urethrotome cuts from before backwards. Civiale's has a concealed knife which can be projected by a screw in the handle, is passed through the stricture and cuts from behind forwards. It is rarely used at the present time and is only suitable for strictures of large calibre.

Technique.—A general or low spinal anæsthetic may be used but, where these are undesirable, local anæsthesia by instilling novocain solution (5 per cent.) into the urethra and retaining it for five minutes, suffices.

The parts are prepared by shaving and washing with antiseptic. The urethra is thoroughly washed out with oxycyanide-of-mercury solution (1 : 10,000) from a douche-can with a urethral nozzle.

The surgeon stands to the right of the patient. The filiform guide is introduced through the stricture, the fine staff screwed on to the guide, and the instrument, well oiled, is pushed onwards. If the calibre of the stricture will admit a No. 8 F. bougie, the filiform guide may be dispensed with, the small bulbous end screwed on the tip of the staff, and the instrument passed through the stricture. The staff lies with the curve in the membranous and prostatic segments of the urethra, the flexible guide coiling inside the bladder.

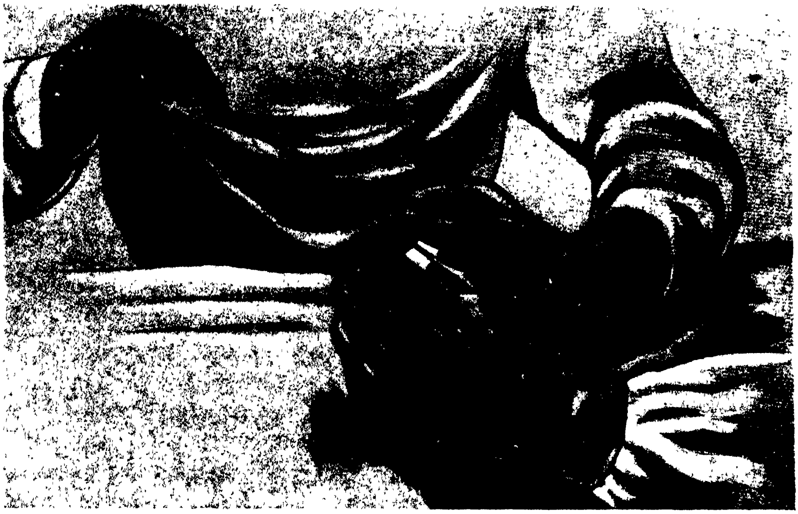

Fig. 1025.—Internal urethrotomy. Hands of assistant holding wings of urethrotome; surgeon steadying penis and pushing triangular knife along guide.

The staff is held by an assistant at an angle of 45°. He leans well over the patient and places one elbow on each of the patient's iliac crests, and grasps the staff with the thumb on the upper surface of each wing, holding the instrument absolutely steady in the middle line.

The surgeon dips the point of the triangular knife in sterile oil, and introduces it into the groove of the staff. The glans penis being raised with the left fingers and thumb, the knife is slipped past the meatus and, with the button held at the end of the rod, is pushed steadily along the urethra until the resistance of the stricture is felt. (Fig. 1025.) A sharp push cuts the stricture, and the knife slips on and cuts any others that may be present. The knife is now steadily withdrawn until the resistance of the stricture is again felt, and a tug at the rod cuts through with the sharp reverse edge of the knife.

Unless the knife be boldly pushed through the stricture, the fibrous tissue will not be cut. The knife rod is withdrawn altogether, and the staff and guide are removed.

A steel sound of 12–14 size is now passed, followed by 13–15 and 14–16. If resistance to the passage of the instrument is felt, the urethrotome should again be passed, this time with the bulbous end in place of the filiform bougie, and the knife again run through the stricture. If the meatus is too narrow to admit a large steel instrument, it should be slit downwards. A coudé catheter (22 F.) is passed into the bladder and the urine drawn off. If the urine is foul, the bladder should be washed with a weak solution of oxycyanide of mercury or a solution of nitrate of silver (1 : 10,000). The catheter is withdrawn until the eye lies just within the bladder, and is tied in. A roll of gauze is placed around the catheter at the external meatus and is held in position by the tapes that secure the catheter. A syringeful of fluid is injected to ascertain that the catheter eye is in the bladder, a plug is inserted into the end of the instrument, and the patient returned to bed.

After-treatment.—The urine is drawn off at frequent intervals by removing the plug from the catheter, or a piece of rubber tubing may be attached, and the bladder drained continuously into a urinal. At the end of forty-eight hours the catheter is removed, and the urethra may be washed with an antiseptic lotion. The object of the retained catheter is to prevent the wound in the urethra from becoming soiled with the urine, which is usually infected. There is less frequently a rise of temperature during the first twenty-four hours after the operation when a catheter is retained than when it is omitted.

After removal of the catheter the patient is kept quiet in bed for a week and then allowed up. A daily irrigation of the urethra may be given if the urine is infected. No instruments are passed for fourteen days after the operation, and then a full-sized metal sound (14–16) is introduced. This is repeated in a fortnight, and if the surgeon is satisfied that no contraction is taking place the intervals between the passage of instruments are increased to three weeks, four weeks, six weeks, two months, three months, four months, six months ; finally, a year's interval is allowed, and if no contraction has then taken place and the urethroscope shows no narrowing the patient is pronounced cured.

Difficulties and dangers.—(1) The fine guide of the urethrotome may break across at the junction with the metal base which unites it to the staff, and on withdrawal of the instrument it is left in the bladder. If this accident happens another guide should be used and the operation proceeded with. With the calibre of the urethra adequately enlarged, the first guide can be removed by a lithotrite, preferably of the type with cystoscopic attachment, or by Young's " cystoscopic rongeur."

(2) After the removal of the urethrotome the surgeon may fail to

pass a metal sound. The difficulty may be due to imperfect cutting of the stricture by a blunt knife, or to a want of boldness in the cutting stroke. The guide of the urethrotome should be replaced by the small bulbous metal tip, the staff re-introduced, and the stricture cut to the full size. Should the surgeon fail to re-introduce the urethrotome staff, a Harrison whip bougie will be the most likely instrument to pass, and this may be followed by the urethrotome staff or by large metal sounds.

(3) At the operation and for the succeeding few days bleeding is usually negligible. Serious hæmorrhage may, however, occur, and a few fatal cases have been recorded. It is most likely when the urine is septic.

When bleeding takes place the foot of the bed should be raised, an ice-bag containing finely crushed ice should be placed on the perineum, and firm pressure applied by a large sand-bag. Sand-bags or other support should be so arranged as to prevent the shoulders of the patient from slipping towards the head of the bed. If a catheter is already in the urethra it should be allowed to remain, as it will assist the pressure and allow the escape of the urine. Without it, bleeding tends to recur on micturition. A hypodermic injection of morphia should be given, and hæmostatic serum or other hæmostatic agents injected. Should these measures fail, the catheter should be removed, the urethra irrigated with hot solution of silver nitrate (1 : 10,000), and pressure re-applied. Finally, should the hæmorrhage resist all treatment, perineal section should be rapidly performed and a large-sized perineal tube introduced into the bladder. Iodoform gauze is firmly packed around this tube or into that part of the urethra from which blood is escaping. Blood transfusion may be necessary.

Late complications. (1) **Urethral fever.**—A retained catheter in the urethra for forty-eight hours prevents urethral fever, and enables the surgeon to wash the bladder in septic cases. Occasionally the temperature rises after the catheter has been removed. If so, the urethra should be irrigated with a weak solution of silver nitrate (1 : 20,000) ; should the temperature not subside, the catheter is re-introduced, retained for several days, and the bladder thoroughly washed.

(2) **Infection and anuria.**—These are rare unless there has been chronic retention with renal back-pressure or pre-existing infection of the kidney, but cases occur where death takes place within forty-eight hours without obvious signs of pre-existing renal involvement.

Where advanced renal disease (ascending pyelonephritis) is present the case is unsuitable for immediate internal urethrotomy ; rapid cystotomy, either suprapubic or perineal, should be performed and the cure of the stricture left to a later date.

Where a high temperature with anuria has supervened, one kidney may be painful, and tender or enlarged on palpation. In such cases a rapid nephrostomy may be needed. In the absence of signs of focal renal infection, treatment should aim at re-establishing renal function by intravenous saline or glucose (5 per cent. solution) and diuretics.

Where the operation is performed in cases complicated by urinary infection, and especially in subjects liable to rigors after instrumentation, hexamine administered intravenously is of prophylactic value. It is given in a single large dose (grs. xxx) in association with sod. salicyl (grs. xii), and caffeine sod. salicyl grs. iii. The proprietary substance " Cyclotropin " has this formula. The sulphonamide compounds are also valuable.

Mortality.—In all cases of stricture the mortality depends more on the condition of the kidneys than on the local condition. The mortality of internal urethrotomy is small. In 4,656 cases collected from the literature (nine observers) the mortality was 0·49 per cent. Watson and Cunningham (" Diseases and Surgery of the Genito-Urinary System," 1909) collected the published results of a number of surgeons, some of which are included in the above results. In a total of 4,686 operations there were 53 deaths, a mortality of 1·1 per cent. At St. Peter's Hospital, during a period of twenty-nine years (1895 to 1923), internal urethrotomy was performed on 2,088 patients, of whom 27 died after the operation, giving a mortality of 1·29 per cent. This remains at the present day a fair statement of the risk incurred.

After-results.—The results obtained vary with the character of the stricture. In a well-defined annular stricture, in a healthy subject, internal urethrotomy will result in a complete cure in a few cases. In a larger number there is recontraction of the stricture after a few months or several years, but the passage of a large metal sound at intervals is usually sufficient to prevent this.

If, however, dilatation is carried out at regular intervals for a year or more after the operation, a large proportion is cured. Irregular attendance, alcoholic indulgence and other causes frequently produce relapses, so that the cutting operation may have to be repeated and the dilatation resumed.

The final group is that of dense fibrous stricture, where there is no prospect of cure by urethrotomy or dilatation.

EXTERNAL URETHROTOMY

The operation of external urethrotomy consists in cutting a stricture by an incision made as a rule through the perineum, occasionally through the floor of the pendulous urethra. The operation takes longer to perform, and the convalescence is more protracted, than in internal urethrotomy. It is therefore reserved for cases where some complication is present which contra-indicates internal urethrotomy.

External urethrotomy with a guide (Syme's operation).—This operation* consists in the passage of a Syme's staff through the stricture, incising the urethra upon this immediately behind the stricture, and then cutting forwards through the stricture.

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* *Edin. Journ. Med. Sci.*, Oct. 1844, iv, 817.

Syme's staff has a straight shaft and a curved terminal portion. The shaft is equal in gauge to a No. 12 E. sound ; it terminates abruptly in a shoulder, and the curved terminal portion is equal in size to a No. 4 E. sound. A groove commences on the shaft about ½ in. behind the shoulder and passes on to the convexity of the fine terminal portion almost to the point of the instrument. (Fig. 1026.)

The pubes, scrotum, and perineum having been shaved and cleansed, the patient is anæsthetized and placed in the lithotomy position.

The Syme's staff is passed, its narrow curved portion entering the stricture, which must be large enough to admit a bougie of No. 4 E. gauge. The shoulder of the staff is arrested by the stricture. An assistant standing on the left side of the patient holds the staff vertically exactly in the middle line, and at the same time supports the scrotum. The staff can be felt in the perineum, and a median incision is made upon it on the distal side of the shoulder. All the tissues down to and including the urethral wall are incised. The urethra is opened about ½ in. on the bladder side of the stricture. A narrow-bladed knife or bistoury is introduced into the groove and carried through the stricture from behind forwards. As it enters the urethra the knife first encounters the narrow portion of the staff and is thus guided to the groove in the broad section. " The stricture has been fairly divided when the staff can be passed to a greater depth without hindrance " (Erickson). The point of a probe-pointed gorget is introduced into the groove in the staff and pushed onwards into the bladder, and the staff is withdrawn. A large perineal tube is introduced along the gorget, and a gush of urine shows that it has entered the bladder. The proper position for the tube is ascertained by withdrawing it a little and injecting a syringeful of warm boracic lotion and watching its return through the tube, by this means making certain that the eye lies just inside the internal meatus. A stitch may be placed through the skin and the rubber tube, or if the tube carries a metal ring with loops it is held in position with tapes. One or two stitches may be placed at the upper end of the wound, some gauze lightly packed around the tube, and a dressing and T-bandage applied. Instead of passing a perineal tube a catheter may be at once introduced into the bladder as in the method employed in the original Syme operation, but an objection raised to this is that the catheter may tend to aggravate further stricture formation.

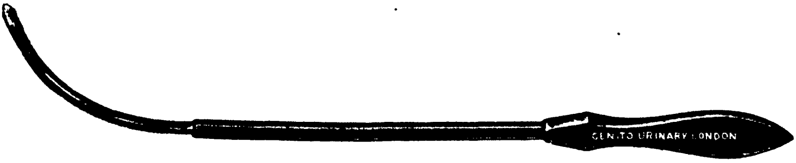

Fig. 1026.—Syme's staff.

The tube should be removed in four days and a large steel sound passed at the end of a week. A large silk-wove catheter should be guided along the whole length of the urethra into the bladder and tied in place, and the perineal wound allowed to heal. Sounds should be passed at lengthening intervals after the operation.

External urethrotomy without a guide (Wheelhouse's operation).*—When the surgeon has failed to pass an instrument through the stricture, the urethra may be opened in front of the stricture and the narrow aperture sought. A fine probe is then passed through, and the stricture slit up on it. This operation was first performed in 1822; Wheelhouse slightly modified the technique and it has been known by his name ever since. Wheelhouse's staff is a straight instrument with a groove which stops short about ½ in. from the end. The rounded end forms a small projection like the end of a crochet-hook on the side opposite the groove. (Fig. 1027.)

The patient having been prepared for a perineal operation, the staff is passed down to the face of the stricture with the groove towards the skin. An incision is made in the middle line of the perineum, which opens the urethra on the groove of the staff. The urethra is incised upwards towards the penis for about 2 in.

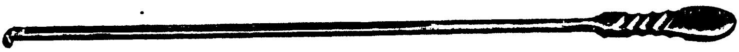

Fig. 1027.—Wheelhouse's staff.

As the groove does not reach the end of the staff, the incision is not carried up to the face of the stricture, and the relation of the stricture to the rest of the urethra is preserved. The staff is now turned round and withdrawn so that the projection at the end hooks up the upper angle of the wound. The mucous membrane of the urethra is picked up on each side, and retracted with a fine thread.

With a good head-light, the surgeon searches for the opening of the stricture, using a fine probe or a grooved director for the purpose. (Fig. 1028.) The thumb of the left hand is placed in the lower angle of the wound and the stricture slightly everted by the fingers pressing on the perineum behind it. Every dark spot is carefully probed and searched. The chief difficulty of the operation is the oozing which obscures the field with blood, and for this reason it is wise not to commence a Wheelhouse operation at the end of a prolonged attempt to pass instruments through the stricture.

When the blood is trickling down from the upper part of the wound, a small plug of wool or gauze tucked in beneath the staff may control the hæmorrhage. But the mucous membrane is often congested and friable, and the oozing comes from the whole surface.

A plug soaked in adrenalin may greatly assist by stopping the oozing. If the opening is not found in what appears to be the face of the stricture, the roof of the urethra should be searched in front of it. The openings of the lacunæ on the roof are often deceptive. Pressure on the bladder may cause the escape of a few drops of urine and disclose the position of the stricture-lumen. Methylene-blue may be injected into the urethra before the operation, so that it permeates the stricture and stains the track.

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* *Brit. Med. Journ.*, 1876, i, 779.

The opening of the urethra having been found, a probe is passed through the stricture and on this a director; the point of the knife follows this guide and cuts freely through the floor of the stricture. The urethra behind the stricture is usually dilated, and a larger director or gorget is readily passed into the bladder. A large catheter is now passed along the penile urethra and is guided into the bladder by the gorget. The perineal wound may be left open, or one or two catgut sutures inserted to draw the edges of the urethra and the perineal tissues together. The catheter is retained in place for four days and then removed. Some urine will probably escape from the wound after removal of the catheter, but this rapidly ceases, and in a few days the wound is dry. The passage of steel sounds is commenced fourteen days after the operation.

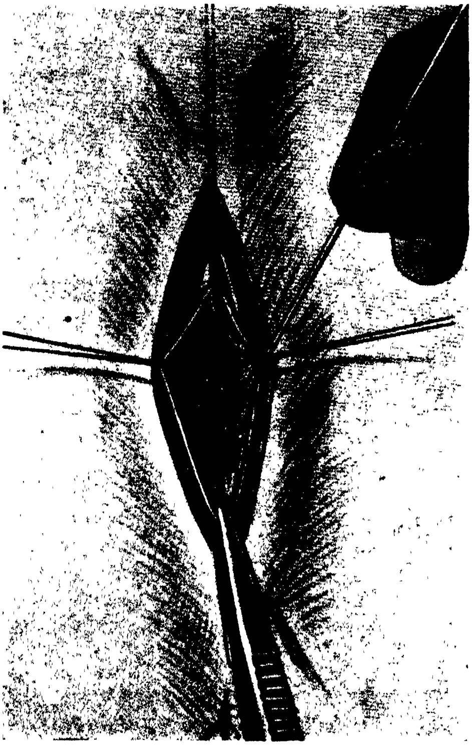

Fig. 1028.—Wheelhouse operation for urethral stricture.

If Wheelhouse's operation fails, one of three procedures may be adopted:

1. **Dissection.**—The urethra may be exposed by dissection behind the stricture, and here opened. This is done by prolonging the incision backwards towards the anus or, if the first median incision is far forward, by making a second incision in front of the anus over the posterior extremity of the bulb, or a curved prerectal incision may be made so as to give a free exposure for careful dissection. In practice the last is seldom necessary. The bulb is first exposed, and when the posterior extremity of this is reached the urethra is easily exposed, since it is considerably dilated at this part. A probe is passed distally through the stricture, and the scar tissue slit up from behind forwards upon this. A gorget or director is passed into the bladder and serves as a guide for a catheter passed along the penile urethra and thence into the bladder.

2. The second method which has been practised in this dilemma is **Cock's operation** of perineal section without a guide.* It was used as a means of draining the bladder in acute retention by incising the dilated urethra and intubating the bladder through this approach. Suprapubic cystotomy has rendered this operation obsolete.

3. **Retrograde catheterization after suprapubic cystotomy.**—In the cases where this procedure is required the bladder is usually distended with urine, so that it is easily exposed and opened. A fully curved metal catheter (Béniqué) is passed along the urethra from behind forwards. It is made prominent in the perineum behind the stricture, and the point cut down upon in the middle line of the perineum. An attempt can now be made to pass a probe forwards through the stricture so that this may be cut from behind forwards. If the probe cannot be passed through the stricture, a sound should be passed down to the front of the stricture and the cicatricial tissue cut through in the middle line until this is exposed. The bladder is drained either through a perineal tube, through a catheter tied in the urethra, or suprapubically, the last being the method most generally adopted.

Dangers of external urethrotomy.—The dangers are due (*a*) directly to the operation or (*b*) to exacerbation of pre-existing disease.

(*a*) **Hæmorrhage.**—Severe hæmorrhage may occur either from the spongy tissue of the corpus spongiosum or from some vessel deeper in the perineum or at the neck of the bladder. It may supervene within a few hours of the operation, or not until eight or ten days later.

When hæmorrhage occurs the patient should be put up in the lithotomy position, the wound opened up and, after turning out the clots, a search made for the source. A stream of hot lotion from an irrigator and a good head-light will greatly assist the search. Any bleeding vessel should be picked up. If a perineal tube is already in the bladder, strips of gauze should be packed around it. If a tube has not been tied in, it should now be passed with the help of a gorget, and the wound packed around it. A broad T-bandage, allowing for the exit of the tube, provides firm pressure on the perineum.

(*b*) The majority of patients requiring external urethrotomy for stricture are poor subjects for operation. Urinary sepsis is present, and this, combined with obstruction and back-pressure, has damaged the kidneys. Chronic bronchitis and emphysema, arterio-sclerosis, and chronic constipation are often present, and very readily lead, from the circumstances necessitating the external urethrotomy or from the effect of the operation itself, to fatal complications.

After-treatment.—The catheter or the perineal tube should be removed on the fourth day, and the urine will for some days drain through the perineal wound. Nowadays suprapubic drainage is frequently established and retained until subsidence of constitutional and local reaction warrant its discontinuance.

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* Guy's Hosp. Repts. 1866, 3s, xii 267.

The bladder is washed daily through the catheter, suprapubic or perineal tube, and when this is removed the wound and the bladder are irrigated by hydrostatic pressure, the glass nozzle of an irrigator being applied to the perineal wound. Silver nitrate solution (1 : 15,000) boric-acid solution, or oxycyanide-of-mercury solution (1 : 10,000) may be used for this purpose.

As soon as possible after the tube is removed the patient should sit for an hour or more daily in a hot hip-bath to which permanganate of potash or boric acid crystals have been added. Steel sounds are passed on the fourteenth day, and at pre-arranged intervals afterwards.

Results.—External urethrotomy is reserved for the most serious and complicated cases of stricture, and the mortality is therefore high. It cannot be fairly compared with the mortality of internal urethrotomy which is employed for milder cases and, as a rule, those not complicated by acute retention.

Grégoire[*] collected 992 cases, with a mortality of 8.8 per cent. ; Thompson[†] published 219 cases, with 6·5 per cent., and Horwitz[‡] 116 cases, with 4·3 per cent. mortality.

At St. Peter's Hospital, during a period of twenty-nine years (1895–1923), external urethrotomy or perineal section was performed in 185 cases, with 11 deaths, a mortality of 5·94 per cent.

In all cases of stricture the prognosis for life depends much more upon the functional state of the kidneys than upon the local condition.

There is no greater certainty of curing a stricture by means of external urethrotomy than by other methods. Where instruments are passed regularly after the operation, cases in which no recontraction is found are not infrequent. Where the patients neglect regular dilatation, and exposure and alcoholic excess are superadded, recontraction of the stricture is almost certain, and it will become hard and cartilaginous. There are cases, however, in which, notwithstanding regular habits and periodic instrumentation, the stricture slowly contracts after the operation and a second cutting is required. In 100 cases of stricture attending the clinic of Sir J. Thomson-Walker at St. Peter's Hospital, external urethrotomy had been performed in 12. In 5 of these it had been performed once, in 2 twice, in 1 five times, in 1 six times. In 3 cases external urethrotomy was followed by internal urethrotomy at a later date.

EXCISION OF STRICTURE

A single stricture may be resected, but multiple strictures are unsuitable for excision. Traumatic stricture is solitary, and there is much peri-urethral fibrous tissue, the removal of which is essential for its cure. This form of stricture is, therefore, usually suited for excision.

Technique.—1. The suprapubic and perineal regions are prepared for operation. Suprapubic cystotomy is performed. The patient is placed in the lithotomy position, and a metal instrument is passed through the stricture. There is no difficulty in doing this, as the excision of a stricture is not an emergency operation in an impassable stricture, but one planned carefully on a stricture in which dilatation and other measures have failed after prolonged trial. A median incision is made for 2 or 2½ in. with the strictured area as the centre. The corpus spongiosum is exposed, and its sheath incised to the full extent of the wound. Careful dissection defines the hard fibrous tissue of the stricture. Where there is extensive peri-urethral scarring, it may be separated from the surrounding structure as a thick ring of yellowish-white, almost cartilage-like tissue. This is detached from the whole circumference of the urethra. The floor of the urethra is incised longitudinally on the metal instrument and the stricture-ring cut. About 1½ in. of urethra, with the stricture as the centre, is thus laid open longitudinally. The metal instrument is now removed. The hardened tissues forming the stricture are defined, and the urethra is cut across transversely through supple mucous membrane and submucous tissue in front of and behind the fibrous area.

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[*] *Thèse de Paris*, 1879.

[†] *Stricture of the Urethra*, 1885.

[‡] *Journ. Cutan. and Gen.-Urin. Dis.*, 1898, xvi, 362.

The approximation of these ends is the next step. When the gap is narrow, the detachment of the urethra already carried out will allow this without tension. But when the gap is considerable, further dissection is necessary. Approximation is obtained by mobilizing the corpus spongiosum, and not by dissecting the urethra out of its surrounding erectile tissue. The corpus spongiosum should be detached from the corpora cavernosa in front of and behind the area of excision until the cut ends of the urethra are easily brought together. (The extent to which this may be done will be discussed later.) The ends of the urethra are now united. Each end has been slit up on the floor for ¾ to 1 in., and the urethral tube laid open. With fine No. 3/0 catgut sutures the edges of the cut ends are carefully united. These sutures include the whole thickness of the urethral wall. If the corpus spongiosum has been mobilized, one or two stitches are introduced into the sheath so as to hold it and prevent tension.

The longitudinal incision in the urethra is carefully sutured so as to re-form the urethral tube. For this purpose a catheter is passed along the urethra, and the edges are brought together over this by a series of interrupted fine catgut sutures. Over this, again, the sheath of the corpus spongiosum is sutured and the layers of the perineum are approximated by catgut sutures, and the skin wound loosely drawn together by silkworm-gut stitches, a drain being placed in an angle of the wound for twenty-four hours to prevent the formation of a hæmatoma. The catheter is then removed. The cystotomy opening is sutured about a Malécot tube.

2. A second method has been recommended by Hamilton Russell.* I prefer this operation; the steps are recognizable in Figs. 1029, 1030, 1031. An inverted V-incision is made with the apex of the V at the central part of the perineum. The ischio-rectal fossa is opened

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* *Brit. Journ. Surg.*, 1915, ii, 375.

up on each side and the membranous urethra and apex of the prostate are exposed, as in perineal prostatectomy.

In many cases it is an advantage to establish and maintain suprapubic drainage for a fortnight. If the bladder has been opened, use may thus be made for retrograde passage of a Béniqué catheter by which the membranous urethra and the urethra behind the stricture are disclosed.

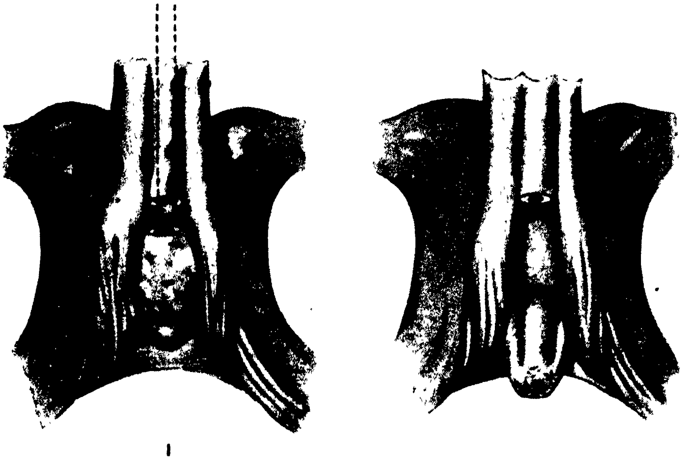

Fig. 1029.—Stages in excision of stricture (Hamilton Russell's method).

(*Modified from British Journal of Surgery*).

1, The urethral staff defines anterior face of stricture and a transverse section is made. 2, The fibrotic mass is separated on all sides, elevated, and dissected backwards until healthy urethra is encountered. A retrograde catheter (not shewn) facilitates discovery of healthy urethra on the bladder side of the stricture, if necessary.

The next stage is the exposure and opening of the urethra in front of the stricture. A median incision is made from the apex of the V forwards. A Wheelhouse staff is passed and the urethra opened, and the margins are retracted by silk-thread stitches. (Fig. 1029.) The urethra is slit back to the stricture. The strictured portion of the urethra, with fibrous extra-urethral mass, is excised, the cut ends are freed by undercutting and their ventral walls incised longitudinally for one inch. The loose ends are brought together by fine interrupted catgut sutures which unite the roof only. (Fig. 1030).

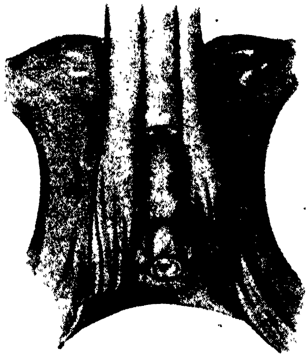

Fig. 1030.—Transverse division posterior to the stricture.

A rubber catheter is passed into the bladder through the perineum at the posterior extremity of the incision and fastened. (Fig. 1031.) The two lateral incisions in the perineum are sutured. No sutures are placed in the perineum in front of the catheter, and the longitudinal wound in the urethra is left unsutured. The catheter remains in for a week and after its removal the perineal wound is allowed to heal by granulation.

The condition obtained here after operation is exactly that which exists after external urethrotomy, and healing in both cases takes place rapidly without the production of scar tissue from the longitudinal incision in the urethral wall. Care should be taken that the oozing from the corpus spongiosum and any other bleeding is arrested.

Three points in excision of stricture are open to discussion.

1. *Drainage of the bladder.*—Many authorities recommend a retained catheter in the urethra, and do not drain the bladder suprapubically. I am strongly of the opinion that, in order to obtain a reasonable certainty of success in many plastic operations upon the urethra, suprapubic drainage must be used. The retained cathetei produces urethritis, and also allows a certain amount of urine to trickle alongside it and soak the line of incision. Hamilton Russell drained by a catheter in the posterior angle of the urethral incision, which was left freely open as a safeguard against infiltration of urine.

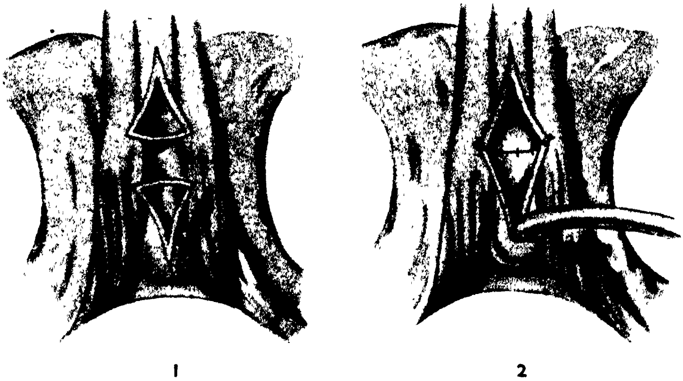

Fig. 1031.—1, The urethral ends are mobilized by separation on all sides and their floors incised longitudinally ; 2, Apposition by suturing reconstructs the urethral roof as a " riband " ; the floor and sides are not sutured. A tube is passed into the bladder and stitched in position.

2. *Suture material.*—Sutures of fine chromicized catgut, size 3/0, are suitable for this work. The fine catgut is absorbed or comes away in the urine.

3. *Extent of tissue removed.*—It is recommended by some surgeons that only a part of the circumference of the urethra be removed and a strip of the roof left to maintain the continuity. Guyon and Albarran * recommended this method, which prevented retraction of the severed ends of the urethra. They argued further that the roof in traumatic stricture might escape injury, and that healing in partial resection was more rapid. Experience has not upheld any of these arguments. With a full incision and free mobilization of the corpus spongiosum there is no difficulty from retraction.

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* " Médecine Opératoire des Voies Urinaires," 1909, p. 923.

An inch to an inch and a half of the urethral wall in its entire circumference may be removed and, if the mobilization of the corpus spongiosum is freely carried out, there will be no difficulty in approximating the ends without tension, *especially if the legs are lowered when the sutures are being tied.* Where the stricture lies far back, close to the membranous urethra, the difficulty is greater, for only the anterior end of the urethra can be drawn upon. As much as 6 cm. (2½ in.) (Burckhardt,* and even 8 cm. (3 in.) (Goldman,†) has been resected with success.

After-treatment.—The urethra should be carefully irrigated daily with boric acid lotion from a douche-can without allowing any undue pressure. Suprapubic drainage is continued for fourteen days, and the tubes are then removed.

A fortnight after the operation, steel instruments are gently passed; Hamilton Russell, however, did not consider this necessary until after the lapse of several months.

Results.—The cases collected by Nogués and Vignard (quoted by Huesco) *Comptes Rendus XIII. Congrès Internat. de Med.*, 1900) show that resection of the stricture in suitable cases is a successful operation, and that permanent cure of the stricture can thus be obtained. In 15 cases there was no recurrence at the end of periods varying from six months to eight years.

In 13 cases of resection collected by Watson and Cunningham (*op. cit.*), in which information was obtained a year or more after the operation, there were only 5 in which the urinary stream or the urethral calibre was normal. Hamilton Russell (*vide supra*) reported 8 cases of severe stricture treated by his method. All were successful in that full-sized bougies could easily be passed after the normal intervals.

RUPTURE OF THE URETHRA

The various types of rupture differ widely in their diagnosis, treatment and sequelæ according to the situation of the injury.

The anterior urethra.—(*a*) The *pendulous* section in front of the suspensory ligament is rarely injured, but a hæmatoma or an abscess following a crush or squeeze may require evacuation. (*b*) The *perineal* section, from the compressor urethræ to the symphysis pubis, is the commonest seat of injury in virtue of its fixation and non-resilient background. The varieties and methods of treatment require more detailed consideration.

(i) **Incomplete.**—Here the dorsal wall remains as a bridge which limits retraction; any of the walls may be contused or the mucous coat lacerated or the whole thickness severed.

(ii) **Complete,** where there is solution of continuity through all coats in the entire circumference of the urethra with contraction and retraction of the ends.

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* Frisch u. Zuckerkandl, *Handb. d' Urologie*, 1904, iii, S 96.

† *Beitr. z. klin. Chir.*, 1904, xliii, 230.

Symptoms and signs vary according to the degree of injury. Passage of blood, inability to micturate (from compressor spasm), a perineal extravasation of blood, or later of urine, and hindrance to instrumentation are the outstanding features, and these guide the policy of treatment. In the mildest cases, where there is no perineal swelling and a catheter passes easily, all that is necessary is to leave it *in situ* for 24 to 48 hours. Although micturition is thus restored, the precursors of stricture exist, and warning of the need for future instrumentation is no small part of the surgeon's duty.

Where there is perineal swelling an incision into it is advisable even though catheterization can be carried out without difficulty. Some surgeons go so far as to say that every case presenting any symptoms of rupture, no matter how slight, should always be provided with such a safety outlet, this being the best prophylactic against stricture (Grey Turner). Where the catheter is checked, operation is always indicated, for a severe injury is of necessity present, requiring not only perineal drainage but often some steps to restore urethral continuity.

Technique.—At the operation a mid-line incision is carefully deepened, great caution being exercised as the urethra, made evident by a rigid instrument, is approached. The extent of damage is defined. If the rupture is (i) *incomplete* it may be possible to coax the catheter through the proximal end into the bladder and perhaps to repair the urethra by two or three catgut sutures. Many surgeons have declared that sutures are unnecessary or even harmful (Rutherfurd), because the gape is only opened out by the lithotomy posture and will close automatically when the legs are extended. If the catheter can be made to enter the bladder, the perineal tissues are loosely approximated, ample room being allowed for suitable drainage. In these circumstances the instrument should be left in for a week. Many prefer suprapubic drainage as the best means of preventing the escape of urine into the perineal tissues, the irritating effect of which is one of the most active agents in stricture formation.

If (ii) *a complete rupture* exists the ends may be separated an inch or more, and finding the bladder end by a direct search would sacrifice valuable time and patience. In such cases an immediate suprapubic incision is made, the bladder is opened and a fully curved metal instrument is passed through the internal meatus and along the bladder end of the urethra until it presents in the perineal wound. The end of the proximal dorsal wall is thus defined and is supported by catch forceps, while through-and-through catgut sutures, which include the corpus spongiosum, attach it to the roof of the distal end. The side walls are then sutured, but before closing the floor the catheter, which,up till now, lay in the penile urethra, is coaxed up into the bladder, perhaps aided by attachment of its end in some way or other to the end of the instrument passed from the bladder (Fig. 1082). Rutherford Morison recommended that a mesial linear incision should be made in either torn end of the floor before suture, as a means of diminishing the risk of stricture. The catheter is retained a week and the suprapubic tube a fortnight. Replacement of the catheter in the third week may be necessary to aid closure of the suprapubic fistula. Three weeks after its withdrawal steel bougies are passed, and subsequently, at lengthening intervals of time.

The posterior urethra.—Rutherford Morison stated long ago in his "Surgical Contributions"* that the surgeon called to attend such a case was probably presiding at the opening of a life-long tragedy. Special attention must therefore be drawn to it on account of the vital necessity for appropriate treatment in the early stages. Being frequently associated with grave skeletal injuries, the state of the urethra may be overlooked, fractured pelvis or femora apparently having prior claim to attention. The surgeon may content himself with the establishment of suprapubic drainage, but it is essential to realize the frequency of interrupted alignment of the urethra, brought

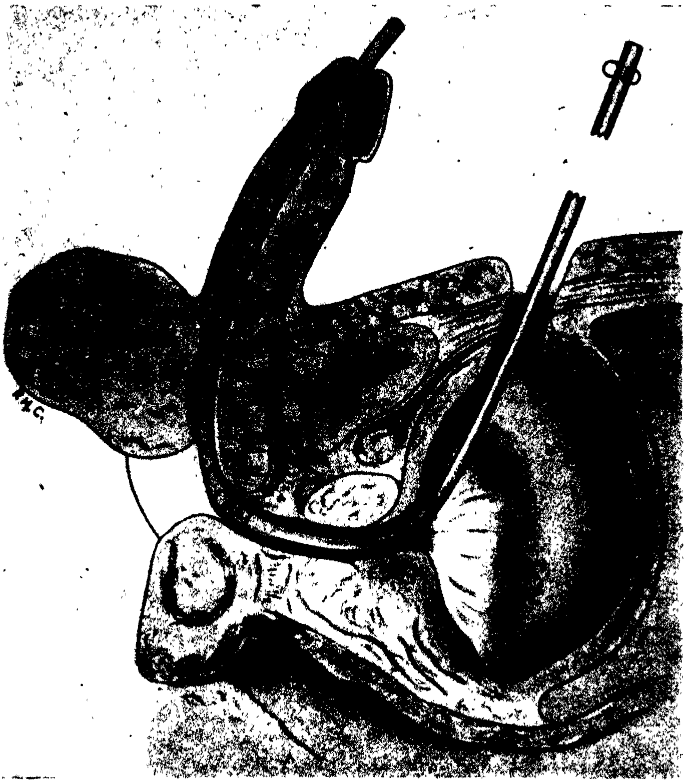

Fig. 1032.—Rupture of posterior urethra.

A method of introducing the "splint" catheter. A curved metal catheter (Béniqué) passed in retrograde fashion has been telescoped through the end of a rubber catheter opened by removal of its blunt tip. The manipulation to effect this is carried out in the perineal wound.

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* 1916, Vol. I, p. 271.

about by dislocation of the severed ends from traction of the bone fragments or fascial tension, or the pressure of extravasated blood or urine. Mal-alignment can only be prevented or corrected by a catheter, to act as an internal splint, and the earliest opportunity for its emplacement must be seized. A fortnight's catheter residence will usually suffice to fix the urethra, and subsequent passage of metal bougies will preserve the line and calibre. Suprapubic drainage is always necessary in these cases.

The surgeon, unless he can find a distended bladder, may be in doubt whether he is dealing with a rupture of the deep urethra or of the bladder base. His exploratory catheter may mislead by tapping the retro-pubic space. If suprapubic incision shows an empty bladder, the injury is vesical ; with a rupture below the internal sphincter there will probably be some urine in the bladder. Suprapubic and prevesical drainage may be all that are justifiable as first-aid measures. As soon as recovery from the shock of the accident and accompanying injuries allows further interference, the catheter is emplaced, either in the whole length of the urethra, if possible, or from the bladder to the perineum through a retro-scrotal stab. In the former case a curved metal catheter of the Béniqué type is passed by way of the cystotomy opening through the deep urethra and is brought out through a transverse incision in the perineum. A stiff rubber or gum-elastic catheter is passed from before backwards through the pendulous urethra until it appears in the perineal wound. Its bladder end is then either attached by a suture to the metal catheter or the metal catheter is invaginated into the end of a rubber catheter, opened to make way for it by removal of its tip (see Fig. 1032). Thus it is drawn up into the bladder, where it will remain. A length of silk attached to the point of this catheter *en demeure* serves to suspend it suitably in the bladder, the other end of the silk being sutured at the suprapubic opening, and this will aid in the subsequent changing of the catheter when necessary.

In the latter case, where a prolonged anæsthesia would hazard the patient's life, the surgeon is tempted to content himself with suprapubic drainage alone. The objection is that the urethral ends rapidly become fixed in faulty alignment, hence it is wise to retain some control of the bladder end of the urethra by a tube drawn up through a perineal stab. This may be rapidly done by passing a pair of long artery forceps downwards through the bladder end of the urethra until the point is felt to project into the perineum. An incision is made over the forceps, which are opened to seize the tube, thus drawing it up into the bladder. It is sutured to the perineal skin. At as early a date as possible, continuity of the urethra is procured by emplacing a catheter in its whole length. The perineal opening is made the centre of a triradiate incision, the anterior limb of which passes forwards for 2 inches towards the scrotum and the lateral limbs outwards and backwards.

The tube is removed and a curved catheter is passed from the bladder in retrograde fashion so that it projects through the perineal opening. A gum elastic or firm rubber catheter is then passed backwards through the external meatus to the perineal wound, and its end is attached to the metal catheter by which it is drawn up into the bladder as in primary catheter emplacement. Suturing the torn ends of the urethra may be possible in the early stages after preliminary trimming; later they will have become too disintegrated to hold stitches. With the aid of the suspending stitch, catheters may be changed frequently, preferably twice a week, the fresh catheter being drawn up by a stitch attached to the distal end of the previous one and this stitch, in its turn, being fixed to the suprapubic wound in an accessible position to serve for further replacements. "Splint" catheterization should be continued for at least a fortnight.

During the residence of the catheter the bladder should be washed through twice daily with nitrate of silver solutions, 1 in 12,000. The suprapubic tube is removed during the third week and the wound allowed to heal. Steel bougies are passed three weeks after removal of the catheter and afterwards at intervals increasing to three months for the first year, subsequently at such intervals as are suggested by the rapidity of closure of a stricture.

Functional results.—The formation of a stricture after rupture of the urethra was almost invariable in cases recorded by the older writers. The result was due to sloughing and septic inflammation. When rapid healing of the urethra is obtained, the canal either remains uncontracted or the stricture which forms is a simple narrow ring, readily amenable to treatment, instead of a tortuous fibrous stricture. Both Kidd,* who followed up twenty-five cases of severe anterior or posterior ruptures, and Wheeler† found that results were somewhat unsatisfactory during the first twelve months, but ultimately were good.

Mortality.—Provided the case is seen before urinary extravasation has taken place, and retention is relieved or prevented by suprapubic drainage, the mortality, apart from shock of coincident injuries, should be negligible. For comparison, it is of interest to study Kaufmann's collected figures. In uncomplicated ruptures (205 cases) there was a mortality of 14·5 per cent. mainly due to urinary extravasation. In association with fracture of the pelvis (48 cases) 40 per cent. died.

OPERATIONS FOR THE REPAIR OF FISTULA OF THE URETHRA

Before attempting to repair the urethra, any complication which co-exists must be treated. Thus, a stricture is freely cut and fully dilated or urethral calculi are removed. No attempt is made to close the fistula where acute inflammation is present, and this especially applies to the fistulæ that follow the rupture of a periurethral abscess.

Efficient drainage of the bladder must be provided; suprapubic cystotomy is the only method of drainage that presents a reasonable certainty of success in plastic operations for repair of major defects of the urethral wall. It is performed either a few days before the operation on the urethra or at the same time.

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* *Trans. Soc. Internat. d'Urol.*, July, 1921, 1 Congrès.

† *Brit. Journ. Urol.*, June, 1929, i, 126.

FISTULA OF THE PENILE URETHRA

The track is always short, and lined by epithelium. A fistula with a very fine calibre may be successfully treated with the galvano-cautery, which destroys the lining epithelium, but in a larger fistula one of the following plastic operations is necessary.

A. **Fistula at the base of the glans penis.**—1. **Loumeau's operation.**[*] A quadrilateral area surrounding the fistula is denuded of epithelium, the lining of the track is removed and the edges are brought together by interrupted catgut sutures. A flap, corresponding to the denuded area in shape and size, on the proximal side of the fistula, is undercut and slid distally until it lies over the raw surface. It is then fixed in place by interrupted sutures to the edges of the raw surface.

2. **Dieffenbach's operation.**[†].—The edges of the fistula are excised by a transverse elliptical incision, and the raw edges united by fine catgut sutures, the knots being tied inwards. The ends of the sutures are drawn through the external meatus, and may be removed by gentle traction a few days after the operation. The under-surface of the glans penis is denuded of epithelium, and a corresponding area is marked out by an incision on the under-surface of the penis or the retracted foreskin, the two surfaces being base to base. The skin is dissected up over the area and turned forwards like a gangway, so that it covers over the freshened surface of the glans, and it is stitched in this position.

B. **Fistula on the under-surface of the body of the penis.**—There is great variation in the size of the fistulous opening and in the extent and density of the surrounding scar tissue. Several operations may be required before the fistula is finally closed. Various operations have been described, and the surgeon will select whatever method appears to be suitable for the type of case with which he is dealing.

An incision is made in the long axis of the penis, with the centre at the fistula. The incision surrounds the fistula, and the edge of the track is excised. The mucous membrane of the urethra and the sheath of the corpus spongiosum are clearly defined. The skin is undercut for a sufficient distance to allow it to come together without tension. Interrupted catgut sutures are introduced to bring the edges of the mucous membrane together transversely, and a second series of stitches unites the sheath of the corpus spongiosum. The skin is united in the long axis of the penis by catgut sutures. No catheter is placed in the urethra.

When the fistula is large and there is difficulty in obtaining apposition of the skin, a longitudinal incision may be made through the skin on each side parallel with the median incision. A bridge of skin is thus formed on each side, and these bridges are united over the fistula, leaving the denuded area to heal without suture. Or a transverse incision may be made below the fistula, and the transverse bridge thus obtained slipped forwards over the fistula (Dieffenbach) ; or a double transverse bridge of skin is used for above and below the fistula (Nélaton) ; or a flap of skin may be turned over from the anterior surface of the scrotum to repair the defect after excision of the fistula. Benedict has recommended grafts of the whole thickness of the scrotal skin for repairing large cutaneous defects of the penis. The flap must be cut half as wide again as the area to be covered, since the dartos muscle causes considerable shrinkage of the flap. The base of the flap is cut at the end of the first week.

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[*] *IX Congrès Franç de Chir.*, Paris, 1895, p. 577.

[†] "Operat. Chir.," i, 588.

Guyon and Pasteau (Thèse de Paris, 1901) closed a large penile fistula by raising three quadrilateral flaps from the proximal and the lateral aspects of the fistula. After the fistula had been pared, the median proximal flap was reflected forwards, forming a new urethral floor. The lateral flaps were then brought together on this and sutured in the middle line, covering the exposed raw surface of the median flap.

Thomson-Walker found two methods useful, in penile fistula and urethral defects, for preventing the ingrowth of epithelium which reproduces the condition :

(1) After repair and suture of the urethra and corpus spongiosum, the skin is freely undercut on each side and at each end of the fistulous area, but without cutting flaps. The anterior and posterior angles of the wound are grasped in forceps and raised up so that the under-surface of the skin on each side of the fistula comes in contact for ½ or ¾ in. in vertical depth. Several mattress-sutures, the number depending on the length of the denuded area, are placed at the base of this ; they are of silkworm-gut and pass from epithelial surface to epithelial surface, the suture at each end being placed beyond the fistulous area. The cut edges are united by interrupted silkworm-gut sutures. If there is tension of the skin, lateral incisions in the long axis of the penis may be made well away from the median wound. The raw under-surface of the skin on either side of the fistula is thus brought into contact for at least ½ to ¾ in., and this apposition extends proximally and distally beyond the fistula.

(2) Where there is likely to be some tension, in cases of fistula or defects of the penile or bulbous urethra, the skin is widely undercut on each side. After repair of the fistula, the skin is turned back on each side and stitched to the skin well out at each side of the fistulous area. The stitches are retained till granulation is established, and the skin is then released.

A cause of failure in plastic operations on the urethra is the occurrence of erections after operation, tearing the stitches. To prevent this the patient is kept under the influence of bromides and small doses of opium, and a rubber bag filled with crushed ice is frequently applied locally.

FISTULÆ OF THE BULBOUS URETHRA

These fistulæ are almost invariably combined with stricture of the urethra, and sometimes also with urethral calculus. The preliminary steps of the operation consist in an internal urethrotomy and, if stone is present, in its removal.

If a single fistula is present the following operation will suffice : The patient is placed in the lithotomy position, and a metal sound is introduced into the urethra. A probe is passed along the fistula until it meets the metal sound in the urethra. A circular incision is made round the fistulous opening, and the fistulous track dissected out until the metal sound can be felt lying in the urethra. When this is reached, the fibrous wall of the fistula is cut across and removed, and any fibrous tissue remaining at the edge of the opening in the urethral wall is clipped away.

The wound may be allowed to heal without suture, the edges coming together when the thighs are approximated ; or catgut sutures may be placed in the urethral wall and perineal tissues, and silkworm-gut in the skin.

Cathelin's operation.*—A large catheter is introduced into the urethra. A circular cuff of skin at the outer orifice of the fistula is dissected up, and the dissection carried along the fistula, which thus forms a funnel. The circular skin-flap and tube is then slit up above and below the fistula so as to form the lateral rolls. These rolls are inverted so that the raw surface is outwards, and are transversely sutured by Lembert's sutures, and the skin sutured over this. This operation is best suited for fistulæ and smaller defects.

Multiple fistulæ opening upon the perineum or scrotum without much fibrous induration have usually one opening in the urethra. The tracks may be excised. The operation entails careful and painstaking dissection. If the individual tracks cannot be dissected out, they must be laid freely open and scraped with a sharp spoon, and as much as possible of the surrounding fibrous tissue cut away. The wound is left widely open and packed with iodoform gauze. Here again the method of undercutting and turning back and stitching the skin already described is frequently of use.

Where there are multiple fistulæ of the perineum and scrotum *with formation of fibrous tissue*, the whole of the fibrous mass should be removed. As a stricture is usually present, internal urethrotomy is performed and a large staff is passed into the bladder. The patient is than placed in the lithotomy position, and a vertical incision made in the middle line of the perineum. This is deepened until the urethra is exposed and the groove in the staff can be felt. A knife is run along the groove and opens about 1½ in. of the urethra. A gorget is passed along the groove into the bladder, the staff withdrawn, and a large rubber perineal tube introduced. The gorget is removed, and the tube clipped with pressure-forceps. The excision of the mass of fibrous tissue which contains the fistulæ is now commenced. The median incision is carried forwards as far as the fibrous induration can be felt. The tissue cuts like a turnip, and several small buried collections of pus may be opened. From the anterior end of the incision another is commenced which passes out on one or other side, keeping at or very near the edge of the indurated tissue, and sweeps round to join the median incision at the perineal end behind the fibrous mass. This curved incision is deepened so as to remove the large wedge-shaped mass of fibrous tissue, which is held aside in toothed forceps as the incision deepens. If a nodule of fibrous tissue lying outside the main mass is felt, it is also freely removed. A similar incision is made on the other side, commencing at the anterior or upper end and working downwards. In this way large fibrous masses which cover an area the size of the palm of the hand are removed, and a gap remains, at the bottom of which lies the urethra.

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* "Chirurgie Urinaire de Guerre," 1919, p. 181.

The wound may be left entirely open or partly closed. When the thighs are approximated the sides come nearer and may meet posteriorly. Without placing any tension on the tissues, the wound should be closed as far as possible anteriorly and posteriorly by silk-worm-gut stitches passed deeply through the skin and subcutaneous tissue. These are left untied until all are in place, and are then tied. No attempt is made to close the wall of the urethra. Part of the wound may remain open, and this is left to granulate, being lightly packed with iodoform gauze. A dressing is applied, and retained by a T-bandage.

After-treatment in operations for fistula.—The wound is thoroughly flushed daily with antiseptic solution. The bowels are kept confined for four days, and on the fourth day the tube is removed and a purge given. Before the action of the bowels the wound should be thickly coated with carbolized vaseline, which protects it from infection, and this is removed after the action is over. At the end of a week or ten days a large steel sound is passed along the urethra, and a gum-elastic catheter may be tied in for a week or more. During healing the patient sits in a hip-bath containing permanganate or boric acid solution for two or three hours daily. Healing takes place in from three to four weeks, and the resulting scar is usually supple and healthy.

REPAIR OF URETHRO-RECTAL FISTULA

All complications must be treated before the operation for closure of the fistula is attempted. To attain success it is essential that the rectal opening should be separated from the urethral opening and that the hole in the rectum be independently closed by suture.

Suprapubic cystotomy is performed, and a drain inserted. The patient is placed in the exaggerated lithotomy position, and a curved prerectal incision is made, extending well out to the ischial tuberosities ;

this is deepened by dissection through the tissues of the perineum. The bulb is identified, and freed posteriorly, and is then hooked upwards where the wall of the fistulous union between the urethra and rectum can be felt. Dissection is carried laterally round the rectum, so as to get well beyond the fistula on either side, and upwards beyond the fistula, so as to isolate it, but in doing this the rectal fistula may be enlarged. Dissection is now carried further, in order completely to separate the rectum from the prostate and bring the fistula well into view.

The next step is to close the openings in the rectum and urethra. The edges of the rectal opening are trimmed and a series of interrupted catgut sutures introduced, avoiding the mucous membrane. This is reinforced by a row of Lembert's sutures. The opening in the urethra is trimmed, and a rubber or gum-elastic catheter replaces the metal bougie in the urethra. The edges of the opening are brought together over this by interrupted catgut sutures in two rows. A rubber drain is placed in the middle line, and the muscular tissues of the perineum are united with catgut sutures. The skin wound is closed around the tube. The catheter in the urethra is removed, and a siphon apparatus attached to the suprapubic drain.

The perineal tube is removed on the fourth day, and the bowels are kept confined for five or six days. The suprapubic drainage is continued for fourteen days, and then the tube is removed and the wound allowed to heal.

OPERATIONS FOR ACQUIRED URETHRAL DEFECTS

The operations here described are applicable where a part of the whole circumference is deficient, as may be the result of traumatic rupture, gunshot wounds or sloughing, as in phagedena.

Suprapubic cystostomy to divert the urine is a necessary preliminary.

(A) Plastic Methods

1. **Repair by sliding flaps.**—A large bougie is passed along the penile urethra, appearing in the defect and disappearing behind it into the posterior segment of the urethra. Median incisions are made over the urethra anterior and posterior to the defect, and the urethral tube is exposed on its under and lateral surfaces for ½ in. A longitudinal incision is made along either side of the gutter, and the skin and mucous membrane are turned over the bougie in two long flaps The exposed ends of the urethra are prepared. The flaps are folded over the bougie so that the skin surface is in contact with the instrument, to meet in the middle line, and are united by a row of Lembert's sutures of fine catgut. At each end the flaps meet the ends of the urethral tube and are carefully sutured to them. The perineal tissues over the newly-formed urethral segment are dissected and brought together with catgut sutures; the skin and subcutaneous tissues are undercut and brought

together by sliding, and united by interrupted silkworm-gut stitches. The bougie is removed, and drainage of the bladder through the suprapubic wound established by means of a White's apparatus.

The urethra is left undisturbed, and drainage continued for a fortnight. The tube is then removed, and the suprapubic wound allowed to heal.

2. **Guyon's double-flap operation.**—For this operation the skin must be supple and free from hair. Guyon cauterized the skin before the operation, in order to destroy the hair.

On one side of the urethral gutter a quadrilateral flap is marked out and dissected up, with its base to the urethra ; a second identical flap is marked out and dissected on the other side of the defect, with its base distant from the urethra. The first flap is turned over, and its surface, which is buried, forms the floor of the urethra at the deficient part. The second flap is made to slide over this so as to cover the raw under-surface of the first flap. (Fig. 1033).

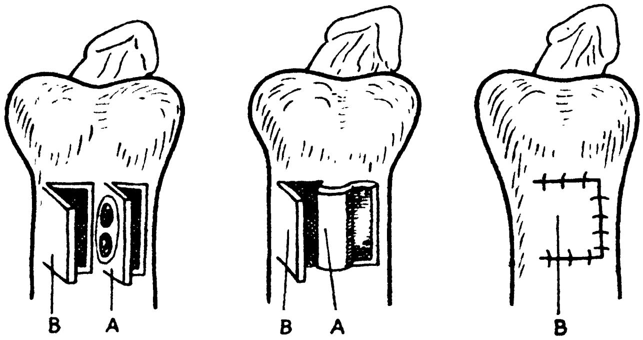

Fig. 1033.—Guyon's double-flap method.

1, Flap A, with base near fistula, and flap B, with base distant from fistula, dissected up. 2, Flap A has been sutured over fistula with raw surface outwards. 3, Flap B is sutured, burying flap A, and thus the fistula is doubly covered.

(B) GRAFT OPERATIONS

The cases suitable for this method are similar to those for which the plastic methods are used. Here also deviation of the urine by suprapubic cystostomy is an essential preliminary to the plastic operation. A great variety of tissues has been transplanted.

1. **Human tissues from the same or another individual.**—The skin has been used in various forms. Keyes used the prepuce. The inner surface of the prepuce was cleaned and packed with antiseptic gauze. A portion of the epithelial inner surface 1½ in. by 2 in. in extent was removed and placed in warm boric-acid lotion. The stricture of the urethra was excised, and the preputial skin-graft stitched in position in the roof of the gap left between the ends of the urethra.

Dittel used a Thiersch graft rolled into a tube. Von Frisch, Le Prevost, Mensel, Norbury, and Thomson-Walker performed similar operations. Strips of mucous membrane have been taken by Albert and Dittel from the lower lip to close urethral defects. Lapiejko operated on three cases, stitching the transplanted mucous membrane to the urethra in front and behind and laterally to the soft tissues of the perineum. In one case the defect measured 7 cm. Portions of mucous membrane taken from other individuals have been used.

Wölfler used mucous membrane from a prolapsed uterus. He incised the cartilaginous stricture of the urethra and allowed the gap to granulate. Strips of mucous membrane several centimetres long and 1 to 2 cm. broad were then taken from the mucous membrane covering a prolapsed uterus, and laid on the granulating surface of the urethral gap without fixing them with stitches. A catheter was tied in position, and the grafts were left undisturbed for five or six days.

Vaginal mucous membrane (Legueu and Wölfler), the appendix (Lener, Streissler, von Augerer, Rothschild), the internal saphenous vein (Tanton, Jaboulay, Carrel, Legueu and Rico), and fascia lata have also been used.

2. **Tissues from animals.**—J. Hogarth Pringle* grafted lengths of bullock's urethra in 3 cases (2 of extensive defects in the urethral wall, 1 of hypospadias), all of which were successful. In his first case 13 cm. of the bullock's urethra were required ; a second graft was necessary to repair a residual fistula. Suprapubic drainage was used in these cases. Gouverneur and Garsin and Legueu used the aorta of a dog ; Walker, strips of intestinal mucous membrane from a rabbit. Adams surrounded a catheter lying in the position of the lost segment with a tube of Baer's membrane.

Results of plastic methods.—By both methods of repair complete restoration of the urethral canal has frequently been obtianed. There is some danger of contraction at the points of union of the repaired with the intact portion of the canal. Sometimes several operations are necessary before the defect is closed.

Good results have been obtained by autoplastic flap methods where the ends of the urethra had deliberately been brought to the surface and the gap allowed to heal over (Pasteau-Iselin), or where this preliminary state developed without premeditation.

Good results were obtained by Mühsam, Cealic, and Legueu, one year, one month, and twenty months respectively after transplantation of a portion of the saphena vein. In a case reported by Gayet and Verguony a post-mortem examination showed that the graft of vein had survived, but a stricture had formed.

OPERATIONS FOR CONGENITAL DEFECTS OF THE URETHRA

HYPOSPADIAS

Three degrees of the deformity are recognized : (1) the glandular, (2) the penile, and (3) the perineal.

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* *Ann. Surg.*, Sept. 1904, xl, 387.

In (1) *the glandular*, the meatus lies in the normal position of the frenal attachment ; it is often narrow. A degree of down-curving may co-exist. In (2) *the penile*, the opening exists anywhere behind (1), perhaps as far back as the peni-scrotal junction, and is usually constricted by a delicate muco-cutaneous fold. The penis is down-curved by fibrosis in the floor of the urethral groove. In (3) *the perineal*, the scrotum is split, the penis is usually rudimentary and the testicles are undescended, the external genitalia bearing a closer resemblance to the female than to the male type.

Operative treatment.—The subject of the glandular variety is so little handicapped that operative interference is seldom required ; the stream may be difficult to direct, but procreation appears to be unhindered. Meatotomy may be necessary if the meatus is small. The details of a method of repair are sufficiently shown in Fig. 1034 (Burghard's operation). The penile and perineal types comprise the majority presented for treatment, and operation is required in all.

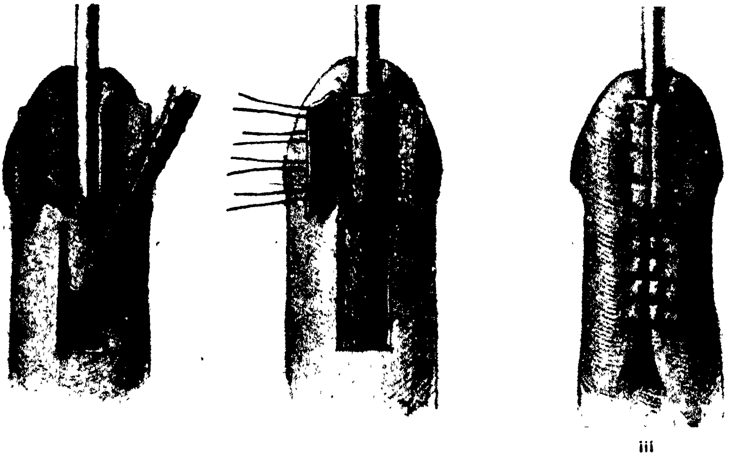

Fig. 1034.—Burghard's operation for glandular hypospadias.
i, Incisions, and partial detachment of basal and lateral flaps. ii, Basal flap turned forward ; suturing of margins and of lateral flaps. iii, Suturing completed.

Operations for penile hypospadias. Edmunds' operation.—Until the method of Edmunds was introduced,* all flap operations were apt to fail from the inability to procure apposition of the flaps without tension owing to the shortage of material available. By mobilizing the prepuce in such a way that it can be slid in two lateral halves to the ventral aspect, Edmunds was able to procure ample skin : (*a*) to cover the raw surface left after full liberation of the fibrotic urethral groove, which had held the penis in its characteristic bent position ; (*b*) to fashion and suture flaps on the Duplay principle, without tension.

The operation is not advisable until the fourth or fifth year, when there is generally enough tissue to handle. Suprapubic drainage is never used, for, although theoretically sound, there is always a risk of sepsis and chronic cystitis and, furthermore, the good results of the operation without this step show that it is not essential.

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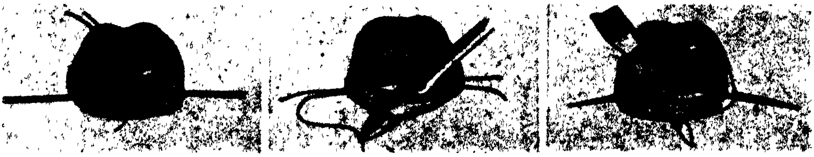
* *Lancet*, Feb. 16, 1926, i, 323. *Hunterian Lecture.* *Med. Press and Circ.*, May 12, 1937, cxciv, 456.

First stage. The preputial hood is "buttonholed" transversely. It is steadied by two laterally placed tension sutures, transfixed, and incised horizontally 1 mm. from, and parallel with, the corona. Sutures unite the edges of the incision and so preserve the buttonhole. (Fig. 1035.) A constricted meatus is slit backwards and a suture passed between the mucous membrane and the skin.

Second stage. (After three months' interval.) This is the most important stage, being designed to correct the down curvature of the penis and to cover the resulting bare area with lax skin. It can be best understood by examination of Fig. 1036. The penis is held on the stretch by a tension suture transfixing the glans. Through parallel incisions made along its margins the urethral groove, with all subjacent fibrous tissue, which may include some cavernous tissue, is sparingly dissected and teased until the tendency to down-curve is removed, and any additional fibrous bands that prevent straightening are cut obliquely. The meatus, as the result of these manœuvres, shrinks towards the base of the penis. The preputial isthmus is divided mesially, allowing the two halves to fall to the sides of the penis in a dog's ear fashion and into these flaps incisions are carried from the distal end of the bed of the urethral groove. (Fig. 1036 (i).) The skin edges of these incisions and the margins of the groove bed are undermined and dissected up. By a teasing process (like a "cook stoning raisins") the lax tissue is opened out into redundant flaps. A series of interrupted sutures is now introduced, the hindermost stitch including the anterior angle of the urinary meatus and the rest picking up the underlying tissue as well as the skin edges to ensure an additional blood supply to the flaps. The finest sutures of catgut or black ophthalmic silk, on round-bodied needles, preferably of the atraumatic type, are used (Fig. 1036 (ii).) Thus the edges of loose skin are sutured (*a*) in the midline, covering the urethral groove, and (*b*) to a narrow, free muco-cutaneous margin close to the corona. The breadth of the



Arthur Edmunds' operation for hypospadias.
Fig. 1035.—Stage I—Securing tube grafts from the prepuce (figs. i, ii, iii).

i, The prepuce, stretched by lateral sling sutures, is transfixed and incised 1 mm. from the corona. ii, Use is made of the slings for suturing the edges of the buttonhole. iii, Application of intermediate sutures to preserve the buttonhole.

(Reproduced, by permission, from Edmunds, *The Lancet*, 1926, Feb. 16th).

organ is much increased at the completion of this stage. (Fig. 1036 (iii).)

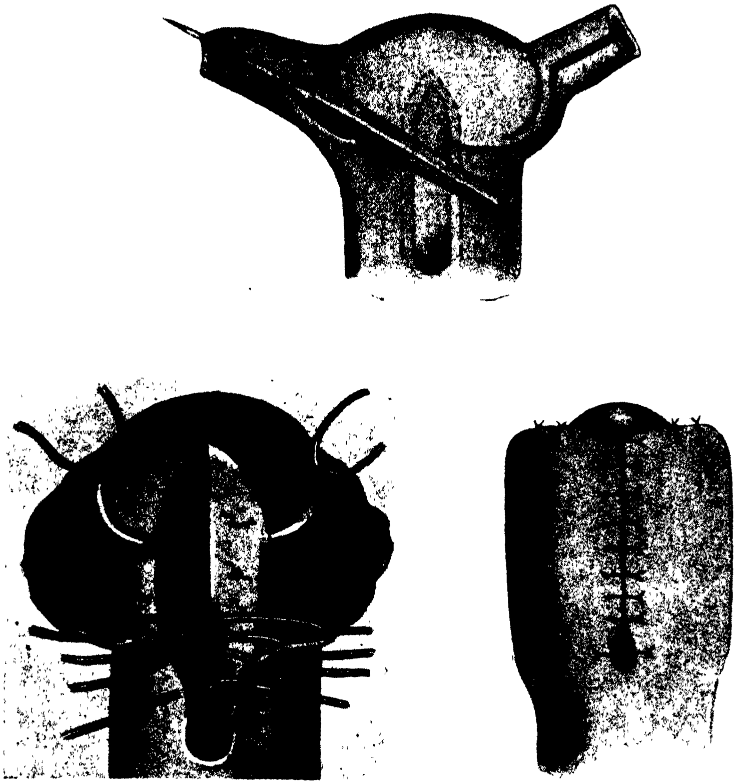


Fig. 1036—Stage II—Overcoming the down-curvature by mobilization of the urethra and transferring the skin of the tube grafts to the raw surface on the ventral aspect of the penis.

i, Preputial isthmus divided. The dotted line indicates the margins of the urethral groove from which enough tissue is dissected up or incised to allow of straightening ; only the minimum amount should be removed. Incisions from the groove are carried outwards at the level of the corona extending into the preputial flaps and downwards as far as the meatus. These are sufficiently deepened into the subcutaneous tissue and, by teasing out the lax skin, lateral flaps are splayed out resembling elephants' ears. The success of the operation depends upon the efficiency of this stage. ii, Application of sutures to the lax flaps to cover the urethral groove. iii, When the above is completed the median sutured edge should almost cover the ventral aspect of the glans. The stitches at the meatus have sutured skin to mucosa ; this may be unnecessary.

(Reproduced, by permission, from Edmunds, *The Lancet*, 1926, Feb. 16th).

Third stage. (Three months later.) A new urethra is formed on the Duplay principle. A narrow lead rod is passed far enough through the meatus to steady the penis, and the operation field is further stabilized by a tension stitch transfixing the tip of the glans, and this is tied to a loop in the lead rod. (Fig. 1037 (i).) Incisions are made on either side of the rod, each far enough from the midline to give, when the two are sutured together over the rod, an amply wide new urethral channel. These incisions, made at unequal distances from the mid-line, are carried well forward, diverging anteriorly at the glans to allow for contraction and retraction of the new meatus ; posteriorly they meet 3 mm. behind the existing meatus. The inner edges of the incisions are dissected up as sparingly as possible to preserve vascularity, compatible with ease of suturing over the lead rod in the formation of the new urethra. Interrupted stitches (of conjunctival silk) are passed from behind forwards, the first including the meatus ; all are passed and tied in such a way that the knots lie within the urethral channel. (Fig. 1037 (ii).) The outer margins of the incision are then sparingly freed and sutured over the new urethral floor with the finest ophthalmic silkworm gut ; vertical mattress sutures, long ago described by Edmunds, are employed. These are tied round parallel rubber strips which act as splints. (Fig. 1037 (iii).) Gauze soaked in 1 in 3,000 flavine and paraffin solution is preferable as a dressing.

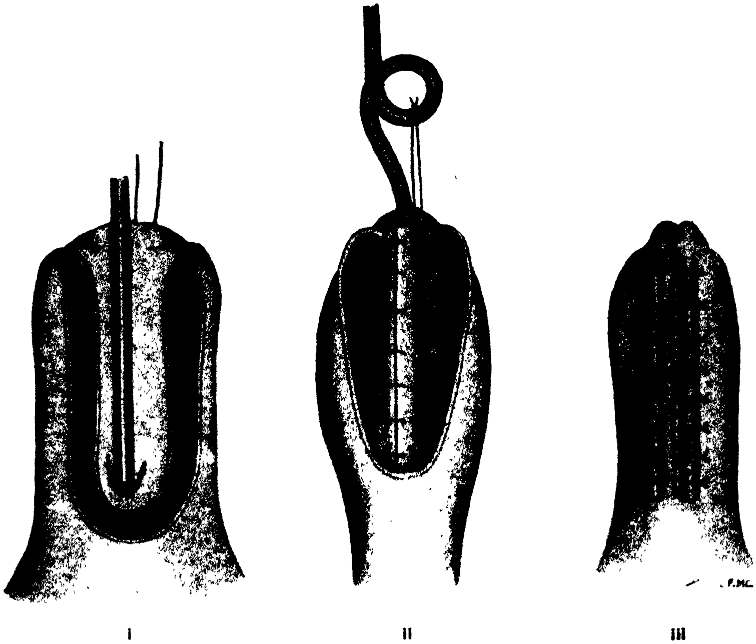


Fig. 1037.—Stage III—Making the new urethra. Duplay's principle.

i, A lead rod is placed in the urethra and a supporting stitch holding the glans is tied to a bend in it. The urethra is formed from flaps raised on either side by incisions at unequal distances from the rod; which meet proximal to the meatus. The rod is the mould upon which the urethra is fashioned. The calibre of the new urethra depends upon the distance between the linear incisions and the laxity of the intervening skin. To preserve vitality skin margins are raised sparingly and should include as great a thickness as possible. ii, The new urethra has been formed by sutures, the knots of which lie within the lumen. The covering layer of skin has not yet been sutured, iii, The covering skin flaps are sutured by the Edmunds' vertical mattress sutures tied over strips of rubber which splint the edges. Note the extent to which the glans is covered by the urethra to provide an anteriorly situated new meatus. This controls the future direction of the urine stream.

(*Re-drawn by permission of Mr. Arthur Edmunds from illustrations in The Lancet and the Medical Press and Circular*).

The precaution of making the urethral incisions at unequal distances from the mid-line avoids coincidence of the lines of union in the two layers. If a fistula forms at the site of the original meatus an incision is made around it. The skin retracts, allowing the mucous membrane to be seen. Finest silk sutures are passed through the mucous membrane and tied, but their ends are left long. A straight needle threaded with fine silkworm gut is passed eye-end first through the meatus and presents through the fistula ; the long loose ends are collected into the silkworm gut loop and drawn outside the meatus. The skin is sutured.

This operation may, if required, be used in a simple form for cure of glandular hypospadias as an alternative to the method illustrated in Fig. 1034, especially if there is a degree of associated down-curvature.

The results of this operation for each form of hypospadias have been eminently satisfactory and, in the majority, such anatomical perfection has been achieved by the originator as to defy recognition of the previous deformity, even in those extreme instances where doubt had existed of the sex to which the individual should be allocated. I recall one case admitted as a female who was some years later sent back to hospital by a new doctor as a " rather imperfect circumcision " ! For further details the reader should consult the original papers cited.

Denis-Browne's operation.*—In this method the prepuce is also adapted to procure laxity of integuments in a manner based upon Edmunds' principles. The prepuce is used as an " insertion " in the dorsum of the penis, as a tailor, if he wished to convert a single- to a double-breasted coat, might put an insertion down the back to procure an excess of material to work with. An incision is made in the middle line of the dorsum from the root of the penis. It diverges at the base of the prepuce to either side of it, the prepuce having been stretched to a hood by suitable traction. The lateral incisions are deepened until they meet, thus leaving an angular ribbon-like strip, which is sutured into the gap left by the retracted edges of the mesial dorsal incision. A sufficient degree of laxity is procured to permit of a subsequent urethral construction by local flaps. The author follows the advice of Edmunds in regard to the necessity for thorough removal of the fibrous urethral groove, and similarly adopts the Duplay method in the urethral construction.

Choice of methods for urethral construction.—Local flaps, tubed pedicles and free grafts can be used. The after-results of Edmunds' operation have proved the merits of local flaps, where provision has been made for them by suitable preparation of the penis. Tubed pedicles, which in other regions have been shown by Gillies to offer wide possibilities, have so far been little used. As long ago, however, as 1901 Mayo † constructed a skin-lined tube from the prepuce and towards the root of the penis, which was divided posteriorly and hinged at the dorsal aspect of the corona. It was then placed in a tunnel, made in the glans with a trocar and cannula, and the free end was thus brought into contact with the existing meatus to which it could eventually be joined.

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* *The Lancet*, Jan. 18, 1936, i, 141.

† *Journ. Amer. Med. Assoc.*, April, 1901, xxxvi, 1157

Revival of interest in free grafts has been stimulated by A. H. McIndoe,[*] who submits that the great success of the Esser [†] principle of inlay grafting in its modern form appears to offer the most reasonable method of constructing a hairless urethra. Nové-Josserand, the pioneer of this method of urethral construction [‡] failed, according to McIndoe, not so much from a faulty surgical conception as from imperfect after-treatment, for stenosis is inevitable unless a distended state of the grafted tunnel is maintained for six months, a period exceeding by a safe margin the contractile phase of grafted skin.

McIndoe's operation.[§]—The operation is performed about the eighth year; the preparation of the penis, however, by the Edmunds' technique, is carried out about the fourth year. A Thiersch graft from the inner side of the arm is laid upon and attached with 6/0 catgut to a length of gum elastic catheter which easily fits inside the barrel of the specially-designed trocar-cannula. Having tunnelled the penis with this instrument from the meatus to, and through, the glans, the handle and point are detached, leaving an open tube into which the graft-covered catheter is inserted. The cannula is withdrawn over the catheter, which is left *in situ,* thus allowing the raw surface of the graft to make and retain contact with the tunnel wall. The catheter is fixed by a simple device. The operation is completed by passing another catheter up into the bladder where it will remain for 48 hours to divert the urine. The graft-bearing catheter is removed on the tenth day and immediately replaced by a similar-sized instrument after an antiseptic urethral-wash. Similar replacements are continued up to six months and act like the gold " sleepers " which jewellers use after ear piercing. When the contractile phase should be over the dilator is left out and end-to-end anastomosis is performed by a flap method closely resembling the Edmunds' modification of the Duplay technique. The special advantages claimed for this operation are that it is fairly simple to perform, fistulæ are unlikely and the new meatus is ideally situated at the tip of the glans. Further, it can be employed successfully and, indeed, has its best application in adults where repeated failures have left the penis in a sheath of scar tissue. In a personal communication McIndoe states that he has completed this operation upon six cases and has a number more under treatment which promise gratifying results.

EPISPADIAS

The following operation was described by Cantwell[||] in 1895. Young,[¶] unaware of Cantwell's article, described the same method independently in 1918. The best age to select is about 10 years.

In epispadias the urethra is represented by a shallow gutter, lined with mucous membrane, on the dorsum of the penis. The meatus is situated at the base of the penis, and opens direct into the bladder. There is usually complete absence of a vesical sphincter. In extroversion of the bladder, epispadias is a part of the deformity. The corpora cavernosa in a normal penis are so intimately attached that it is impossible to separate them without injuring the bodies themselves. In epispadias they can be readily separated, being connected only by some areolar tissue.

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[*] *Brit. Med. Journ.*, Feb. 1937, i, 385.

[†] *Ann Surg.*, 1917, lxv, 307.

[‡] *Journ. d'Urol. Med. Chir.*, 1914, v, 393.

[§] *Amer. Journ. Surg.*, Oct. 1937, xxxviii, 176.

[||] *Ann. Surg.*, xxii, 689.

[¶] *Journ. Urol.*, 1918, ii, 237.

Perineal drainage is first established. A finger is introduced into the bladder through the gaping meatus, the perineum pushed down, and an incision made through which a perineal drainage-tube is introduced. Two parallel incisions are made on the dorsum of the penis from the symphysis pubis to the extremity of the glans, along the lines of union of the mucous membrane and the skin. The incisions are deepened to the corpora cavernosa, and carried backwards to join above the bladder opening.

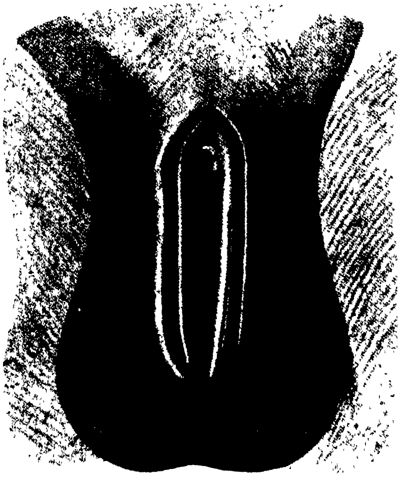

Fig. 1038.—Operation for epispadias : incision.

A flap is made of the whole urethra attached at the base of the penis. This is held aside, and the corpora cavernosa are separated by blunt dissection. (Figs. 1038-9.) The urethral flap is laid in the gutter thus formed, and held in position by two sutures, through mucous membrane and skin, tied on the under-surface of the penis. A catheter is then laid in the urethra, and a canal is formed by continuous suture of the free edges of the mucous membrane. Above it the corpora cavernosa are brought together and retained by a continuous suture. The skin can usually be brought together over this. Some deep sutures are placed in the skin and fat of the pubes. Cantwell leaves the catheter in the newly formed urethra for several days in order to prevent contraction.

Young detaches the urethra from one corpus cavernosum only, leaving it attached to the other corpus, which is rotated sufficiently to bury the new urethra. This provides a better blood supply for the new urethra.

This operation provides no control over the escape of urine, and in cases where there was previous incontinence, an apparatus to collect the urine will have to be worn. Subsequently, however, Young * described two cases, one male and one female, where co-existing incontinence had been cured by combining an intravesical operation in which the bladder and urethra are laid into one by a long

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* *Journ. Urol.*, April, 1936, xxxv, 417.

anterior incision made on a curved clamp as a guide. The sphincter is sutured anteriorly and the bladder closed, except for a small drainage tube; before proceeding to reconstruction of the urethra, and penis in the male.

The successful formation of a sphincter permitting a controlled stream capable of being projected beyond the penis, has led to the opinion amongst some surgeons that the formation of a completed urethra may be regarded as superfluous.

A. R. Thompson * introduced an operation in which he utilized the rectus muscle to form a sphincter. Certain anatomical facts were ascertained before performing the operation. The twelfth dorsal nerve supplies the lower two-thirds of that portion of the rectus which lies below the umbilicus. Two terminal branches are formed: the one passes upwards, and the other downwards. The ilio-hypogastric nerve does not supply the lower end of the rectus; the lower portion of the rectus can therefore be dissected away from its sheath without the surgeon seeing or damaging the nerve supply. The blood supply is drawn from the deep epigastric, which runs beneath the muscle, adherent to it rather than to the sheath. Although a case was recorded where the patient held his urine for one-and-a-half hours when in bed and, when he voided urine, the stream was projected forwards and with force, on the whole this ingenious attempt to provide a vesical sphincter has not stood the test of time and is no longer advised by its originator.

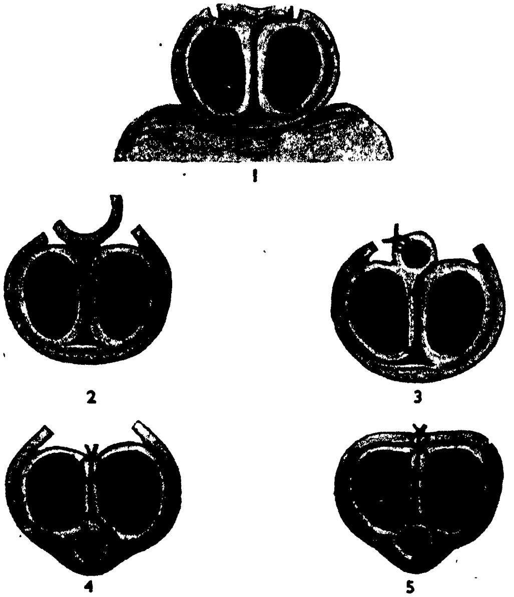

Fig. 1039.—Operation for epispadias: penis in section, showing (1) lines of dissection, with scrotum below; (2) dorsal gutter dissected and corpora cavernosa separated; (3) urethra formed of dorsal gutter, and complete dissection of right corpus cavernosum; (4) urethra sunk between and below corpora cavernosa; (5) completed operation.

The problem in urethral defects with urinary incontinence lies in the choice between efforts at construction of the urethra supplemented by formation of a sphincter, either from the natural one or by plastic adaptation of an extraneous muscle, and discarding the natural outlets by substituting the large bowel for the bladder, and the anal sphincters. Grey Turner and others have shown the results of ureter

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et, 1920, ii, 790.

implantation into the colon to be so satisfactory that there are good reasons for preferring this operation. Further, it can be carried out at a considerably earlier age, any time after the fourth year, at the most only two operations will be required, and the child and parents will be spared the anxiety of long delays and repeated operations, which may only end in failure.

CHAPTER XLV

OPERATIONS ON THE PENIS & TESTICLE

By JOHN EVERIDGE

CIRCUMCISION

THIS operation is subjected to variations according to whether the patient is an adult or an infant. In the latter, healing is more rapid, sensibility to pain less acute, and postoperative erections negligible. Hence a speedier operation, not requiring the same refinement of technique as in an adult, can be done.

The operation in an infant.—Besides speed, care must be taken not to remove too much or too little skin or mucous membrane, to avoid damage to the glans, and to procure hæmostasis. The surgeon should also examine the external meatus to make sure that this is not unduly small.

Since general anæsthesia has been responsible for many tragedies in this minor operation, it is most important to insist that there shall be someone present who has no other duty than to administer the anæsthetic. The not uncommon practice of one and the same person giving the anæsthetic, and then hurriedly performing the operation, cannot be justified. Sometimes it may be necessary to evade the risk by doing without anæsthesia and operating in the first three or four weeks of life, when sensibility to pain is low. The assistance of a capable nurse who can be relied upon to hold the child satisfactorily is essential. She should be seated on a low chair, with a large firm pillow on her lap. The child's legs should be firmly grasped just above the ankles and held up in the lithotomy position ; at the same time she checks movement of the arms by anchoring them beneath her elbows. The surgeon will be seated opposite the perineum. The end of the prepuce is held in a pair of forceps, and a narrow clamp or sinus forceps placed dorsi-ventrally downwards and forwards. The skin beyond is then cut across with sharp scissors, leaving the connective-tissue covering of the mucous layer exposed. After removing the clamp, three artery forceps are placed on the cut edge of the mucous membrane : two, dorsally, adjacent to the midline and one, ventrally, in the midline. A mesial cut is made with scissors between the dorsal forceps to a point just distal to the corona. The mucous membrane is peeled off the glans, firm adhesion between the two occasionally offering some difficulty. The cuts are carried laterally parallel to the corona, meeting mesially below. Bleeding points are picked up with forceps, the ultimate hæmostasis being secured by their inclusion in sutures. Four sutures are usually all that are necessary, two lateral, one dorsal, and one ventral. More may be required for hæmostatic purposes. They are best introduced on a straight needle with a narrow cutting edge, and fine catgut is the most suitable material. Better apposition of the edges is secured when the skin is traversed before the mucous membrane. Care should be taken to avoid puncturing the glans, as troublesome hæmorrhage might result.

The operation in an adult. (Fig. 1040.)—The clamp method may be suitable, but as a rule is not so satisfactory and is unnecessary. Three artery forceps are placed on the free edge of the prepuce, two dorsally and one ventrally. One blade of a pair of blunt-pointed scissors is introduced between the prepuce and glans, and a mesial cut made to a point ¼ in. distal to the corona. Care should be taken to avoid undue traction on the forceps, as otherwise it might be found when the skin retracts that the cut had extended to the body of the penis, an accident which could also have been prevented by marking the line of the encircling cut before traction. The prepuce is then divided laterally from the proximal point of the first incision. At the frenum the two incisions will meet. All spouting arteries should be caught and tied. A continuous suture of fine catgut, uniting skin to mucous membrane, is introduced to secure good apposition as well as efficient hæmostasis of the smaller vessels. A suitable dressing consists of ribbon gauze soaked in 1 : 1,000 flavine and liquid paraffin, equal parts, adapted to the coronal region. A loose piece of gauze is placed over the whole penis, and removed when micturition takes place.

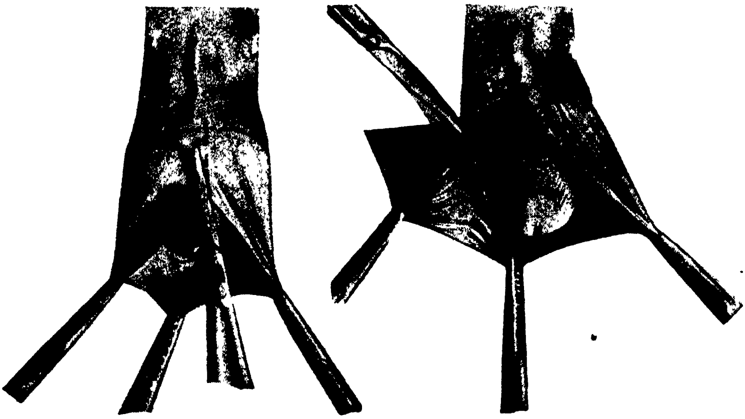

Fig. 1040.—Circumcision : dorsal view.

Anæsthesia in circumcision.—In adults the more recently introduced narcotics, evipan or penthothal, will generally provide a sufficient depth and length of anæsthesia, if preceded by omnopon and scopolamine.

If **local anæsthesia** is preferred, a solution of 1 per cent. *novocain* is introduced by a series of punctures with a very fine hypodermic needle into the deep layers of the penile skin at the level of the corona, producing a series of wheals which become confluent and form a circle.

To anæsthetize the mucous membrane the needle must be introduced into the loose, submucous cellular tissue by direct puncture if the prepuce can be retracted; if it cannot, by piercing at the mucocutaneous margin of the preputial orifice. Assuming that it is introduced into the right layer, the novocain spreads readily, ballooning the loose connective tissue. The region of the frenum is the most sensitive, and special care is necessary to infiltrate freely in this situation.

Nerve-blocking of the dorsal nerve of the penis carried out at the base of the organ is less certain, and for this operation would probably have to be reinforced by local infiltration.

Phimosis is not necessarily treated by complete circumcision.

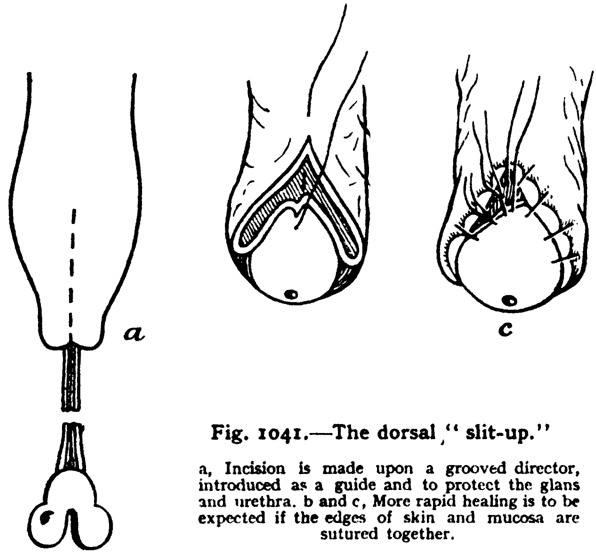

Fig. 1041.—The dorsal " slit-up."

a, Incision is made upon a grooved director, introduced as a guide and to protect the glans and urethra. b and c, More rapid healing is to be expected if the edges of skin and mucosa are sutured together.

This operation is often refused by the patient, and unwarranted, since the only objects may be to gain approach to the meatus for aseptic instrumentation, or to provide opportunity for sub-preputial cleanliness. Modified circumcision, by which the glans remains protected by its natural covering, is especially desirable for adults and the aged in whom permanent exposure of the glans may be a source of irritation. A dorsal " slit-up " will give the necessary exposure for aseptic instrumentation, and a few sutures to approximate the edges will give a neater result preventing healing by granulation and fibrosis such as might cause relapse. (Fig. 1041.) *A short frænum* may be lengthened by an incision made transversely and sutured longitudinally. (Fig. 1042.)

In some cases, where the prepuce on retraction presents a tight cord-like ring in the coronal sulcus (the first stage of paraphimosis), permanent relief may be obtained by one or two longitudinal incisions which divide the whole thickness of the constricting band, but do not, of necessity, encroach into the free prepuce. If these incisions are sutured transversely, sufficient length will be gained to secure laxity even during turgescence. (Fig. 1043.)

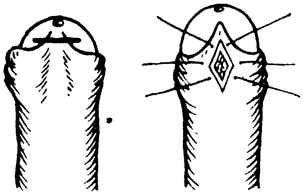

Fig. 1042.—Lengthening the frænum preputiæ.

The frænum is stretched by retraction and divided transversely. It is sutured with apposition of the edges in the long axis of the penis.

Relief of paraphimosis is required in the presence of irreducible retraction of the prepuce with œdema and, perhaps, sloughing from vascular strangulation. A grooved director is coaxed under the prepuce and constricting ring in the midline, dorsally, and all tissue to it is divided. The œdema rapidly subsides and replacement is carried out. Cosmetic circumcision can be performed at a later date, if necessary.

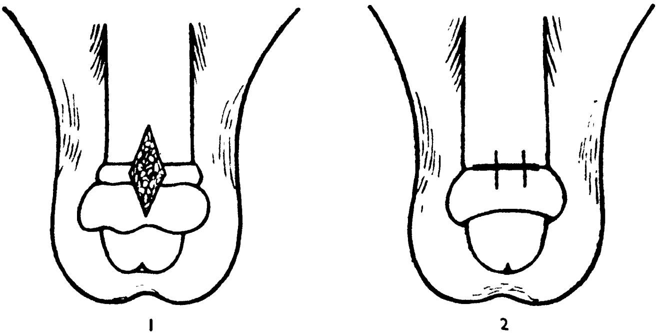

Fig. 1043.—Operation for paraphimosis.

1, Division of the constricting ring. 2, Suture of the skin and subcutaneous tissue in transverse axis.

OPERATION FOR CONTRACTED MEATUS

Meatotomy.—A narrow-bladed knife is inserted and a downward cut made, taking care to include a sufficient length of the urethra. The passage of a large bougie will prove the adequacy of the incision. Subsequent dilatation is regulated by the rapidity of recontraction.

The tendency to relapse is diminished by suturing the cut edges of the skin to the mucous membrane, which is drawn out of the depth of the urethra, into which it has sunk, by toothed forceps. Raw surfaces will be covered in this way and, if primary union takes place, healing by granulation and future fibrosis is reduced to a minimum. (Fig. 1044.)

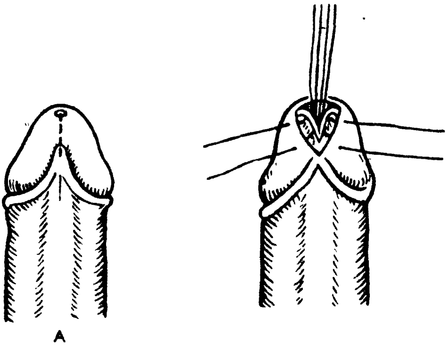

Fig. 1044.—Meatotomy.

The meatus is incised towards the frænum (A). In most cases suturing is unnecessary, but, if desired, it may be carried out as in (B), the sutures transfixing the skin and mucous membrane.

AMPUTATION OF THE PENIS

This operation is rarely called for in conditions other than malignant disease. The nature of the amputation is controlled by the situation and extent of the growth. Reluctance to perform an operation producing so far-reaching a psychological as well as physical defect has encouraged surgeons to welcome a prospect of cure by radium and X-ray therapy. Both these radio-active agents have their place, and after radium, especially, hopeful results are seen in certain types of growth, but as yet the end-results do not appear to warrant a reversal of the older teaching—except for the most superficial growths, or for the purpose of cleaning up a foul fungating mass as a preliminary to operation.

When the growth is limited to the prepuce, glans, or corona, and the organ is long enough to leave a stump lying well clear of the scrotum, a partial amputation may be employed. When, on the other hand, the corpora cavernosa are implicated, complete amputation offers the best hope of eradication. In all cases, excision of glands in the groin should be part of the routine. Where the extent of the growth has warranted complete amputation, extirpation of the inguinal glands and surrounding cellular tissue is as much a part of the operation as is the clearing of the axilla in radical amputation for carcinoma of the breast, and, similarly, block excision of the whole area, to include all lymphatics in an unbroken chain, should be the objective.

For carcinoma of the penis the surgeon has the choice of the following methods of treatment :—

1. Partial amputation (*a*) with excision of inguinal glands; (*b*) with radiotherapy to the inguinal fields if glands are very extensive or the general condition precludes excision.

2. Total amputation with (*a*) or (*b*) as above. Radiotherapy may be used as a supplement to excision, where excision may not be complete.

3. Radium therapy to the penis (*a*) alone in very early or very advanced cases ; (*b*) as a preliminary to some form of amputation ; (*c*) with dissection of the lymphatic fields ; (*d*) with X-ray therapy to the lymphatic fields, if too advanced for excision and glands can be felt in the iliac fossa.

4. Emasculation with block dissection of the lymphatic field, supplemented by X-ray therapy.

I. Partial Amputation

Two types of operation are available—(*a*) the flap ; (*b*) the circular or elliptical. A tourniquet should be employed, and for this either a piece of rubber tubing or a rubber catheter is suitable.

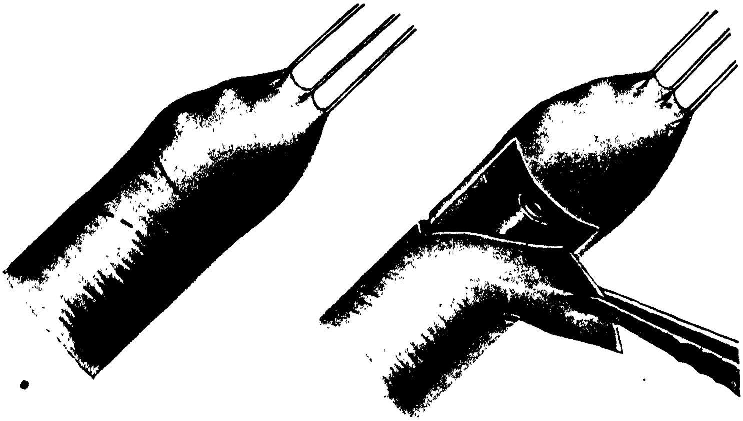

Fig. 1045.—**Partial amputation of penis with long ventral flap : incision, raising of flap, and section of urethra.**

(*a*) **The flap method.**—Dorsi-ventral flaps are employed; and use may be made of a long dorsal and short ventral flap, or vice versa. For the latter an advantage claimed is that the urethra piercing the long flap will be at some distance from the line of apposition and hence contamination of the wound with urine, and consequent irritation or sepsis, is less likely.

When the **long dorsal flap** is used, it must be half the circumference of the penis in width, and in length equal to the diameter of the organ. The ventral flap is about ¾ in. long. Both flaps, including all tissue to the tunics of the corpora cavernosa and corpus spongiosum, are dissected back to their bases. (Fig. 1045.) A narrow-bladed knife is introduced between the urethra and the corpora cavernosa and a length of urethra (about ¾ in.) is isolated by passing it forwards, and cut across distally. The corpora cavernosa are transfixed and divided at the level of the basal attachment of the flaps. Ligatures having been placed upon the dorsal vessels and those in the corpora cavernosa, the tourniquet is removed, and any other bleeding-points are dealt with. There is usually considerable oozing from the spongy tissue, and in the corpora cavernosa this may be checked by suturing the tunica albuginea over the cut surface. The dorsal flap is punctured, and the urethral stump brought through the hole. The end of the urethra is then split and each half is sutured, not to the margin of the puncture, but to the skin beyond it. By this method a rosette of redundant urethra is left, and this is the only way to prevent subsequent contraction of the new meatus. (Fig. 1046.)

In the **long ventral flap** method there are no essential differences in the operation, apart from the relative lengths of the flaps. The button-hole to transmit the urethra is made in this flap.

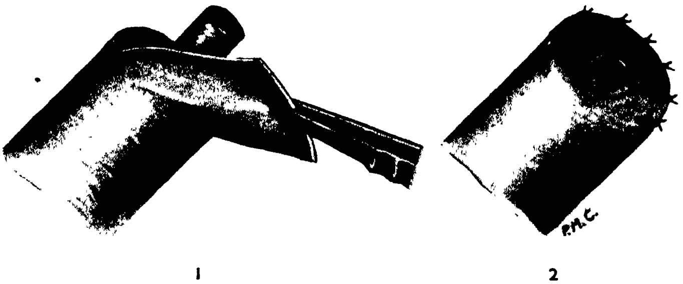

Fig. 1046.—**Partial amputation of penis.**

1, Flap and segment of urethra prepared. 2, Urethra taken through buttonhole in base of flap and sutured to the skin beyond its edges ; flap sutured in position.

(*b*) **The circular amputation.**—A circular incision is made around the organ ¾ in. in front of the position where the corpora cavernosa are to be cut across. The skin is retracted and the corpora cavernosa are incised vertically until the urethra in its spongy investment is exposed. The urethra is dissected forwards and separated for ¾ in. before it, in turn, is cut across at this distance anterior to the divided corpora cavernosa. The skin edges are sutured, leaving a gap through which the urethra will pass. The urethra, projecting through this opening, is incised longitudinally in its dorsal and ventral walls thus leaving ½ in. long flaps which are sutured to the neighbouring skin.

The elliptical amputation is performed in a similar way, except that the circular incision is made obliquely downwards and forwards. It appears to present no special advantages over the other methods.

At the conclusion of the operation a catheter may be introduced through the new urethral opening, but as this may aggravate sepsis it is better avoided in most cases.

Complications.—Oozing from the cavernous tissue is very apt to give a troublesome hæmatoma. Remembering this, care should be taken, during the operation, to leave a sufficient interval between the interrupted sutures. A hæmatoma is likely to suppurate, and pus may even track up in and around the corpora cavernosa, requiring evacuation.

Stenosis of the urethral outlet may occur in spite of the precautionary measure of splitting the new orifice. A careful look-out should be kept for this contraction ; should it occur, dilatation or incision will be required.

II. Total Amputation

The method of complete eradication usually adopted varies little in detail from that originally described by Sir A. Pearce Gould.* He pointed out the necessity for removing the corpora cavernosa in their entire length, but did not, in the original communication, extend the scope of the operation to the lymphatic field.

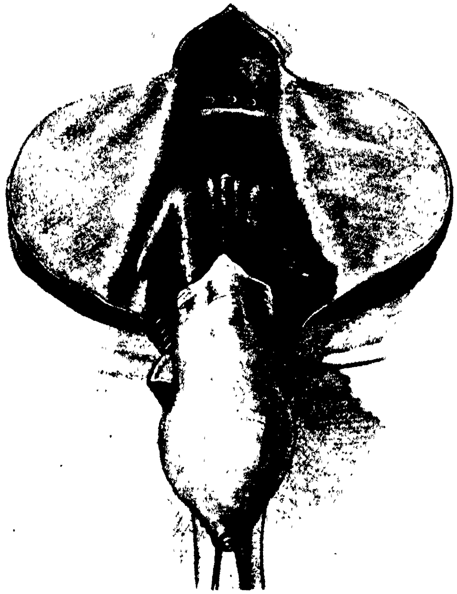

Fig. 1047.—Total amputation of penis : crura partly detached, dorsal vessels ligatured. The edges of the split scrotum are seen retracted.

Technique.—With the patient in the lithotomy position and a steel bougie in the urethra, the base of the penis is encircled by an incision which is continued backwards through the middle line of the scrotum and perineum, ending about 1 in. in front of the anus.

The penis is separated from the pubic symphysis by dividing the suspensory ligament, and thrown downwards. (Fig. 1047.) The scrotum is split through the septum and, as the perineal part of the incision is deepened, the urethra is identified and the bulb exposed. (Fig. 1048, A.)

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* *Lancet*, 1882, i, 821.

The bougie is removed, and the urethra separated from the triangular ligament. The divergence of the corpora cavernosa is now apparent, and their crura, which are closely attached to the pubic and ischial rami, will require separation from those bones by a raspatory as far back as the body of the ischium. A piece of urethra 2 in. long is isolated anterior to the triangular ligament (Fig. 1048, B.) and held in catgut slings while the edges of the whole length of the wound are brought together by silkworm-gut stitches except for gaps left for the urethra and a rubber drain. By arranging the first of these gaps vertically below where the urethra leaves the triangular ligament the urethra is given the shortest and most direct course; moreover, the excess length already prepared will allow ½ to ¾ inch redundancy beyond the skin, which can be fashioned into lateral flaps. These flaps are stitched to the surface at a distance from the edges of the wound, without tension, and allowing for the possible increased tension caused by post-operative œdema.

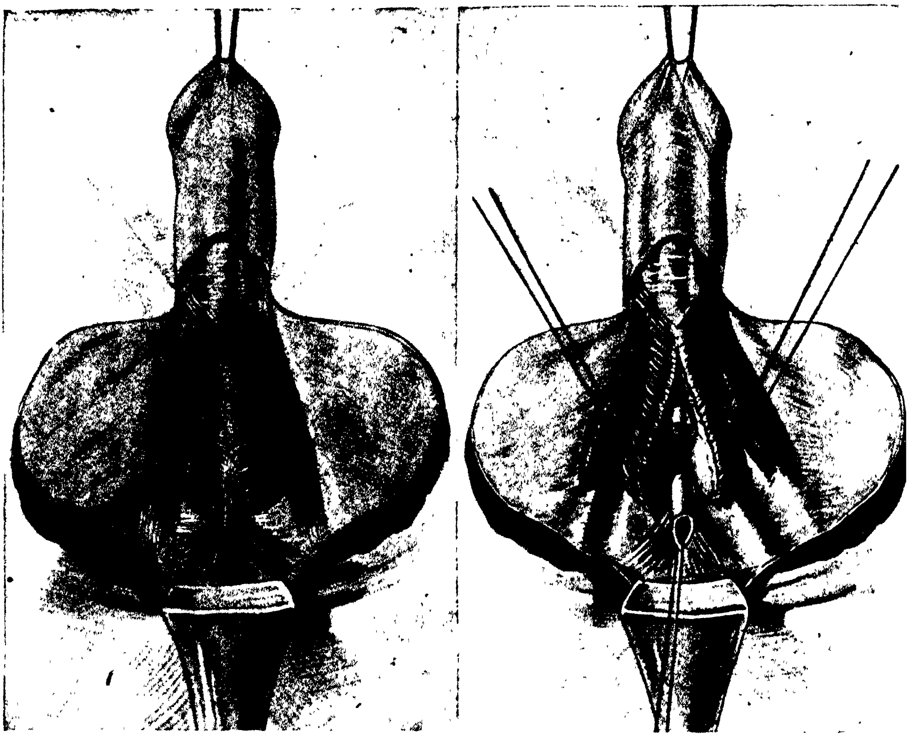

Fig. 1048.—Total amputation of penis : A, incision and dissection of perineal muscles ; B, dissection of crura and section of urethra.

If the inguinal regions are to be cleared on the same occasion, the procedure described should be preceded by this important step. Curved incisions should be made in each groin, extending from the anterior superior spines down to the base of the penis. Through these, all glands, fat, and fascia are freed *en masse*, elevated externally, and thrown down towards the penis to avoid division of the lymphatic vessels. This step involves removal of subcutaneous fat and deep fascia down to the surface of the external oblique and over an area at least 2½ in. on either side of the incision. In this way all the gland-bearing structures are removed, including those over the upper part of the femoral vessels. The principal vessels requiring ligature are the superficial circumflex iliac, epigastric and external pudic. These may be of considerable size and must be carefully caught as they leave the trunk of the femoral. Near the large vessel gauze stripping is very helpful. The internal saphenous vein will usually have to be divided.

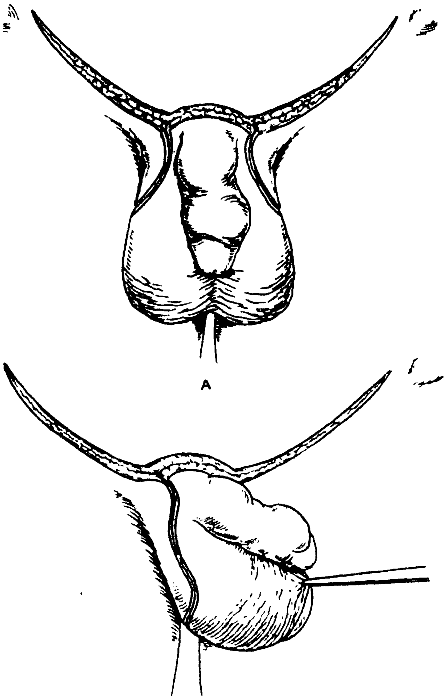

Fig. 1049.—Incisional approach for amputation of the penis with emasculation.
(From Diseases of the Penis and Urethra. D'Arcy Macrea.)

Removal of the testicles and scrotum at the same time is advisable on the ground: (1) that the tissue might otherwise be the seat of recurrence; (2) that the scrotum might be an embarrassment in the new method of micturition; and, especially (3), that it is desirable for physiological reasons to procure complete emasculation whenever the whole penis has to be sacrificed.

Where castration has been decided upon, a curved transverse incision is made from groin to groin, crossing the middle line immediately above the penis. Lateral incisions include the sides of the scrotum, and meet in the midline just behind it. (Fig. 1049.) Thence a short median incision is made to a point 1 in. in front of the anus. The inguinal regions are first of all cleared, and the cords tied and divided at the external abdominal rings. The cords and all cellular tissue, glands, testes and scrotum are thrown downwards in continuity. The penis, the corpora cavernosa and urethra are dealt with as in the operation described above, and the wound is sutured, the same precautions being taken with the urethral stump.

It does not appear necessary to leave a catheter *in situ* at the completion of these operations. Trouble with subsequent micturition is unusual, and stenosis of the new urethral orifice is less often met than after partial amputation. The initial shock from the operation may be somewhat severe, but the result in its bearing on the function of micturition is usually very satisfactory.

RADICAL PARTIAL AMPUTATION (H. H. Young's operation)

Hugh H. Young, believing that the probability of local recurrence is minimal, although observations of earlier surgeons did not support this view, devised a more conservative amputation, even in the presence of a growth of the type generally considered to be outside the scope of partial amputation. No conservatism is, however, introduced into the clearance of the lymphatic field, the inguinal area and intervening lymphatics being attacked on most radical lines. The operation is commenced peripherally, the clearance of the groins being the first step, and dissection exposes the inguinal canals, the external rings, the cords and coverings. The crural region is also assiduously cleared, and fascia and fat accompanying the cords into the scrotum are followed and dissected away. The divided corpora cavernosa and spongiosum are covered by a skin flap from the dorsum of the penis. This flap does not include Buck's fascia, which has been dissected away from beneath it.*

RESULTS OF OPERATIONS FOR CARCINOMA OF THE PENIS

Demarquay, referring to the operative sequelæ, mentions retraction of stump, retraction of the urethral orifice with abscess, fistula, stricture of the new meatus, bacterial infection of the inguinal glands, recurrence, generalization of the disease, aggravation of the poor general condition, mental changes, loss of sexual power. To these might be added œdema of the legs from interference with lymphatic return after clearance of the groin.

Among the earlier authors, Butlin (" Operative Surgery of Malignant Disease," 2nd edit.) collected 65 cases treated by amputation before 1900 : in the majority the inguinal glands were not removed ; 23, i.e., 35 per cent. showed no recurrence in 3 years. Of the rest there was penile recurrence in 3, and in 6 cases in the inguinal glands. The exact nature of the operations upon the penis and glands is not stated. Barney* collected 100 cases. He found 39 per cent. of recurrences in the first year, and 12 per cent. after the fifth year. Of these, 21 cases were local, in the penis or stump ; 2 were in the groin alone, and 3 in both groin and penis. Thus, it is clear that freedom from recurrence in the conventional three-year limit is no indication of a cure. In this disease variability in malignancy is most striking, many cases seeming to run an almost benign course. Indeed, Barney mentions one patient who refused operation and eloped ; eleven years later he was still alive.

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* For further details of this operation reference should be made to its detailed description in "Practice of Urology," H. H. Young, 1926, ii, 648.

Only by reference to the statistics of surgeons collected before the radiotherapeutic era can the results of operative measures alone be fairly assessed, for probably in every modern centre, since the advent of radium and X-ray therapy, these measures will have been given trial and will have influenced the effect of operative surgery. Thus, all recent statistics can only be derived from a combination of methods. (See p. 2156.)

RADIUM AND OTHER AGENTS IN THE TREATMENT OF CARCINOMA OF THE PENIS

Modern methods include the high frequency current, which may be used as a coagulating or cutting agent. The cutting current is useful for removing massive proliferative growths as a prelude to radium therapy or amputation ; indeed, it may be used for some of the steps in an amputation, but should be avoided in skin incisions where primary union is expected as it may delay healing. The coagulating current is especially valuable in reducing a highly vascular neoplasm and will then be used in combination with the cutting current.

Radium.—Either the element in screened needles or its emanations in the form of radon seeds may be used. Surface or interstitial application is as yet a matter of individual choice, the inclination naturally being to embed in small circumscribed growths, but according to Hutchison,† there is a tendency to discard interstitial methods and to use only surface application, by means of which the whole shaft of penis can be homogeneously irradiated. He uses a standard cylinder 10·7 cm. long, 5 cm. across in external diameter, 1 cm. thick, giving an internal diameter of 3 cm. The radium needles are placed around the periphery of the cylinder in four bands or belts, the long axis of the needles being parallel with the axis of the cylinder. Each band has six 1 mg. needles (1·5 cm. active length, 0·5 mm. P + filter) at equal distance around the circumference. This mould is applied for 240 hours, giving about 5,000 to 6,000 *r* dose. He reports a series of 10 cases over 1 year, but under 2 years after treatment :—alive and well, 9 cases, of which 5 were treated by radium alone and 4 by radium previous to amputation.

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* *Ann. Surg.*, 1907, xlvi, 890.

† *Brit. Journ. Radiol.*, 1935, viii, 306.

Certain types of growth respond more readily than others. The hypertrophic varieties without much infection and with little infiltration are the most favourable ; the ulcerating varieties are less so ; nevertheless, it is often surprising how, occasionally, a foul fungating ulcer will heal with minimal scar formation. The infiltrating type, where the substance of the glans or corpora cavernosa is involved, seldom reacts favourably to radiotherapy, and earlier amputation is required.

Radium is little use for glandular nodes ; excision or X-ray treatment, independently or combined, are accepted as the best measures.

Thus the tendency of treatment to-day is :—

(*a*) To treat the primary growth with radium. If there is failure to respond, or recurrence, to amputate,

(*b*) To clear the inguinal fields by excision *in every case*, assuming that they are in an operable state, otherwise deep X-ray therapy should be used.

RESULTS OF COMBINED METHODS OF TREATMENT

The question of treatment of the inguinal lymphatic field is most controversial for, although glandular metastases are to be expected in all cases sooner or later, yet the observations of Barney, Barringer and Dean and others find the incidence to be no higher than 40 per cent. This figure, no doubt, is low enough to influence adversely the tendency to perform radical or prophylactic surgery according to accepted principles, especially in view of the age and constitutional state of the victims and, additionally, on account of the established therapeutic value of X-radiation. The natural tendency therefore would be, if these explanations are valid, to resort to inguinal dissection only when the glands are easily palpable and after attempts to reduce them, by treatment of the septic element in the primary growth or X-ray therapy, have failed. Statistics must show poor results of gland excision if these principles are adopted ; especially is this to be expected in centres more liberally equipped with facilities for therapeutic radiation. So far it has not been possible to study results in a series of cases where prophylactic inguinal dissection has been employed as a routine whether glands are palpable or not. The nearest approach to such a series is supplied by Lewis* reporting upon 34 cases operated upon over a period of 10 years by the H. H. Young's technique (see p. 2154). Of this number, 15 were alive and well, 6 five years, 2 four years, 2 three years and the rest under three years after operation. Similarly, energetic surgèry produced satisfactory results in the collected statistics of Leighton† who treated surgically 34 out of 48 cases, 3 cases by partial amputation, 5 cases by partial amputation with inguinal dissection, 1 case by total amputation, 11 cases by total amputation with inguinal dissection, and 14 by total emasculation. Of the 29 cases traced, 19 are living from

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* *Journ. Urol.*, 1931, xxvi, 295.

† *Amer. Journ. Cancer*, March, 1932, xvi, 251.

6 months to 25 years after operation ; 3 out of 4 cases treated by röntgen or radium therapy alone were dead.

Barringer and Dean's analysis of 36 cases* gives full details of the treatments selected and their individual results. Biopsy reinforced clinical diagnosis in a large percentage of their cases.

Horn and Nesbitt† similarly studied 37 cases treated by combined methods, but in these, excision of inguinal glands was employed in only 5 cases and then associated with total amputation. Of 4 cases treated by partial amputation and X-ray therapy to the inguinal glands, 1 survived for 10 years. Eleven were subjected to total amputation with X-ray treatment to the glands, and of these 6 were alive from 4 to 8 years. Of 5 cases treated by total amputation and groin dissection, only 1 was known to have lived (4 years). That groin dissection was withheld in the great majority suggests that in the few cases where it was performed all other measures had failed, so that no conclusions can be drawn from these figures on the question of gland excision.

A. Dean‡ found that only superficial growths without inguinal metastases could be satisfactorily treated by radiation alone, or by a conservative operation. Of 18 cases first seen with metastases 82 per cent. were known to have died.

The question of the best treatment for inguinal glands, therefore, remains unanswered. Undoubtedly the delay in seeking advice is largely to blame ; Barringer and Dean estimated that an average of 14 months elapsed between the appearance of initial symptoms and the commencement of treatment. It is therefore reasonable to suppose that if early treatment could be instituted, as in the case of the tongue, and, especially, prophylactic glandular measures, namely, surgical excision or X-radiation, a better outlook could be anticipated. Cade§ observes that with inoperable metastases external radiation by high voltage X-rays or teleradium may. produce some palliation with diminution in size and help to clean up foul-smelling ulcers.

THE OPERATION FOR VARICOCELE

The main problem of this operation is the selection of cases, for in the majority of patients the condition is purely psychological and will either disappear on marriage or continue without producing symptoms. Few subjects of varicocele are likely to develop any complication other than pain. Thrombosis and rupture of the veins from direct injury do occur, but are extremely rare. The personal equation is the intangible factor in pain ; those who declare that they suffer much from the pain of varicocele are precisely those who may complain later of painful scars or of severe symptoms from a hydrocele which may subsequently develop. The development of varicocele in men over thirty suggests some new lesion, such as malignant kidney. Undoubtedly, when varicocele is associated with an unusually pendulous scrotum operation is often indicated, especially in those whose occupation will take them to tropical countries, particularly if hard horse-riding is likely to be required.

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* *Journ. Urol.*, 1924, ii, 497.
† *Ann. Surg.*, 1934, c, 180.
‡ *Amer. Journ. Roent.*, 1926, xv, 26.
§ *Proc. Roy. Soc. Med.*, 1939, xxxii, 1509.

In the course of examination it must be remembered that a co-existing hernia may be responsible for the pain. Neuralgia testis is another cause, and this naturally will not be relieved by a varicocele operation. The worst combination is varicocele with sexual hypochondriasis and in these patients surgical measures must always be avoided.

OPERATION FOR RADICAL CURE OF VARICOCELE

The high or the low operation may be performed.

The high operation exposes the veins by an oblique incision extending from the external ring to the base of the scrotum. The coverings of the vas and veins are cleared and the vas with a few veins and the spermatic artery are separated from the main mass of varicose vessels. The latter are freed from the ring to the testicle, and double-clamped at either end. Stout catgut ligatures are placed in the grooves made by the end clamps and are securely tied, and the veins are divided close to the intermediate clamps, thus leaving a mass distal to the ligatures to safeguard against slipping. One end of each ligature is left long, so that these may be tied together, providing a support for the testicle. This support may be further strengthened by placing sutures between the upper and lower occluded vein ends. Some prefer to place the ends side by side and to surround both by encircling ligatures. Great care is required to ensure perfect control of the cut vessels, as many cases of severe hæmorrhage have followed a less cautious technique.

The low operation approaches the veins through an antero-external, vertical scrotal incision which divides the dartos as it is deepened towards the vessels. The further steps of the operation are the same as for the high approach.

In cases associated with a **pendulous scrotum** not only should the ligatures of the central and peripheral ends of the veins be tied together to elevate the testicle, but a segment of scrotal skin should be removed. This may be done either by excising an elliptical-shaped piece on the anterior surface, or—and perhaps preferably—a transverse segment may be removed from both sides. The latter is conveniently done by taking hold of the excess portion of the scrotum with an intestinal clamp. All tissue on the distal side of this clamp is then removed with scissors, and a series of mattress-sutures introduced to check bleeding and to evert the skin edges, which are then sutured by interrupted silkworm-gut stitches.

Results.—Although the risks of operation are almost negligible, the end-results often leave much to be desired. Corner and Nitch* reviewed 100 cases, of which one-fifth still suffered pain, and in 4 per cent. the patients were even worse for the operation. A hydrocele was present in 23 cases and a spermatocele in 2. In 2 there was recurrence. Fibrosis and atrophy of the testicle are both found in a high percentage of the cases (55 and 21 respectively). However, although these figures reveal a somewhat unsatisfactory state of affairs, quite 70 per cent. of the patients were comfortable and well satisfied with the operation. As a rule, interference is determined by the regulations of some public service, but if the operation is performed only when there are definite indications and with cautious case selection the results are good.

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* *Brit. Med. Journ.*, 1906, i, 191.

OPERATIONS FOR HYDROCELE

The operations commonly performed for hydrocele are either (*a*) extirpation of the parietal layer of the tunica vaginalis, or (*b*) eversion of the sac (Jaboulay's operation). In both, the tunic may be approached through an inguinal or a scrotal incision, according to the individual practice of the operator. The wound should heal well in either operation ; the former route, however, presents opportunity for dealing with a hernial sac, should one co-exist.

(*a*) **The radical operation.**—All coverings should be peeled off the tunic before opening the sac. The distension by the fluid, especially if accentuated by suitable pressure on the scrotum, will assist this, and will also help in freeing the vas and vessels. If all the coats are got rid of before cutting away the sac, there will be fewer vessels to bleed and to form what may be a troublesome hæmatoma. The vas and vessels should be separated from the sac before it is opened. Having opened the sac and evacuated the fluid, the surgeon cuts away the parietal serous layer with scissors or diathermy knife, $\frac{1}{4}$ in. from the testicle and epididymis. A continuous fine catgut suture is then introduced all along this cut edge to check oozing. (Fig. 1050.) In spite of the greatest care to procure hæmostasis, it is necessary to insert a rubber drain, which is introduced into the lowest part of the scrotum, whether the high or the low operation has been adopted ; it should be left in for three days.

(*b*) **The eversion operation.**—In this it is not so necessary, though still advisable, to separate all the coverings, neither is delivery of the whole sac through the wound essential ; hence the operation may be carried out very speedily. An opening is made into the tunica, and after the fluid has escaped it is enlarged to allow the testicle to be brought through it ; by this manœuvre, eversion of the sac will be procured. One or two sutures placed in the edge of the tunic behind the testicle will maintain the eversion, but care must be taken that these are not drawn too tightly, otherwise interference with the blood supply of the testicle will result. Though simple and rapid, this operation is not suitable in all cases. Thus, when the tunic is voluminous or much thickened and adherent, eversion may be difficult and, should it be attempted, a troublesome lump will remain which is often, especially in hypochondriacal patients, a source of pain and mental disturbance.

Excision of a spermatocele.—Spermatoceles, if of a size sufficient to warrant removal, may be approached by the inguinal or the scrotal route. Sometimes they can be completely enucleated without being opened; if this is not possible the sac-wall is cleared, as in hydrocele excision, opened, and cut away with scissors from the epididymis, precaution being taken to leave a sufficiency to hold a continuous hæmostatic suture.

After removal of spermatoceles and as a precaution against "recurrence" it is necessary to examine the epididymis carefully for, in a number of cases, it will be found that this structure presents a few small cysts or a cystic condition, the forerunners of future spermatoceles. Partial or complete epididymectomy is the best safeguard against relapse, but where the residual cysts are very small and rudimentary some surgeons rely upon multiple puncture.

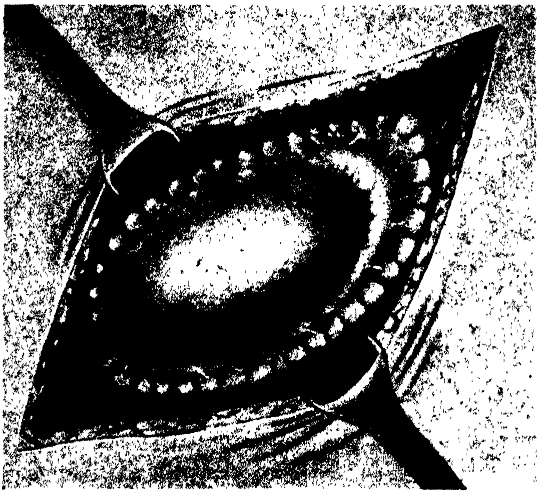

Fig. 1050.—Radical cure of hydrocele.

A continuous hæmostatic suture has been placed in the stump of the parietal tunic.

In removal of hydroceles and spermatoceles the high-frequency cutting current has been found useful in the dissection of the sacs on account of its hæmostatic action.

Results of operations for hydrocele.—Excision of a hydrocele, if efficiently performed, is very rarely followed by recurrence. This might, however, result from re-collection in a pouch such as the digital fossa, or where a bilocular hydrocele was present and the second sac not recognized. The results of eversion are not so good, and recurrence has been met. Further, atrophy of the testicle may result if the vas or vessels have been compressed by the margins of the opening in the tunica vaginalis.

OPERATIONS ON THE EPIDIDYMIS AND VAS

INCISION OF THE EPIDIDYMIS—EPIDIDYMOTOMY

This operation may be performed for suppurating foci, or to relieve tension in acute epididymitis or hæmatoma. It has been more widely adopted in the last few years, but has long been recognized as of value. Indeed, Pirogoff used epididymis puncture in 1852, and Smith in 1864 reported 1,000 cases with good results[*]. The type of operation usually adopted was described by Hagner in 1906. It consists in making a 2-in. vertical incision in the skin of the scrotum over the line of junction of the testicle and epididymis. The tunica vaginalis is opened and the testicle and epididymis delivered. The epididymis is palpated and, if an area of softening is found suggesting an abscess, it is incised longitudinally and the pus evacuated. Multiple small collections of pus, however, are more often found and, for their identification, multiple punctures with a cataract knife or an exploring syringe or a diathermy needle are advised. The testicle is then returned, and a rubber tissue drain introduced. The incision in the scrotum is partially closed by two silkworm-gut sutures, which may be tied over a drainage-tube to prevent cutting into the skin.

The operation, conforming as it does to surgical principles, is sound, and deserves more attention. The epididymis in acute inflammation is no longer a patent tube but a series of small abscesses containing necrotic material. C. D. Allen[†] has advocated the operation in gonorrhœal epididymitis because it (1) shortens disability ; (2) completely relieves pain ; (3) immediately relieves toxæmia ; (4) prevents destruction of healthy tissue ; and (5) may help to prevent recurrence. According to his statistics, gathered from a military hospital, the average duration of the disease in cases treated in this way was nine days. One patient was fit to return to duty in four days.

An interesting and important consideration is the possible effect of this operation in preventing sterility in bilateral epididymitis. Of 4 bilateral cases in which the operation had been performed on both sides, Hagner found that spermatozoa were present in the semen in 2, and were absent in 2. In the former, operation had been done within two days of the onset of the attack. Cunningham, in 6 bilateral cases, was able to demonstrate spermatozoa in 4 ; 2 of these patients became fathers.

In tuberculous epididymitis, incision and curetting of the epididymis are sometimes employed where caseous foci are present. This is the most conservative of all operative measures employed in tuberculous disease of this organ, and in patients who can devote themselves rigidly to a perfect course of general treatment, it appears to be fully warranted.

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[*] Quoted by H. W. McKay, *Journ. Urol.*, March, 1921, v, 255.

[†] *Mil. Surg.*, Oct. 1921, xlix, 439.

LIGATURE OF THE VASA EFFERENTIA—THE STEINACH II OPERATION

Niehans, under the influence of Steinach, is responsible for the publicity of this operation in England as well as in Switzerland. By ligature of the efferent ducts of the epididymis, it is claimed that the symptoms of prostatism are ameliorated, but failure is acknowledged in cases where the gland is so enlarged that nothing short of enucleation can be effective. The ligature, it is suggested, by damming back the testicular hormone, drives it into the circulation where it activates the inhibiting hormones of prostatic development, whether these be of the pituitary or of other elements of the endocrine chain. The operation remains *sub judice* in this country. Results are difficult to assess, for up to now there is only clinical evidence and very little, if any, pathological proof.

The **technique** is extremely simple. Under 1 per cent. novocain anæsthesia, a 1½-inch incision over the cord in the scrotum opens the tunica vaginalis. The testicle is delivered and a needle, threaded with silk, transfixes the base of the digital fossa. The stitch is carried round and falls into the gutter between the head of the epididymis and the upper pole of the testicle, and is tightly tied. This includes all the ducts. If no gutter exists, a shallow incision is made, allowing the ligature to fall into place without puckering or causing undue tension in the tunica albuginea of the testicle or epididymis.

The operation has the merit of being entirely danger-free, and no greater harm can ensue than a hæmatoma of the scrotum, which might suppurate and be followed by atrophy of the testicle. I know of several patients upon whom prostatectomy had subsequently to be performed. The main objection to the method is that in cases bordering on uræmia valuable time may be wasted in exploiting this operation, especially as it is put forward that good results may not be obtained for many months. During this probation period uræmia may have become established beyond hope of recovery.

EPIDIDYMECTOMY

This operation is rarely called for in any condition other than tuberculous disease. Occasionally it is required in cystic disease, and it is sometimes performed in conjunction with vaso-testicular anastomosis. In tuberculosis, removal of the epididymis with conservation of the body of the testicle may be considered in all cases where there is reason to believe that the tuberculous disease has not spread into the testicle. In some cases this will not become evident until the operation is in progress, when orchidectomy can still be carried out if necessary. In cases of doubtful diagnosis it is unwise to make an incision into, or to take a scraping of the epididymis or of the body of the testicle, for fear of dissemination of the disease locally or to distant parts. It is better to treat a doubtful case as one of tuberculosis than to delay operative measures too long.

Views on the nature and extent of removal of diseased tissue in tuberculous epididymitis vary. Some recommend conservative measures, such as incision and scraping, while others believe in radical removal of the whole of the genital tract, including the whole length of the vas, the body of the testicle, the seminal vesicles, and the prostate. Most surgeons adopt an intermediate plan and are content with removal of the epididymis and vas up to the internal abdominal ring, preserving the body of the testicle as opportunity permits. In many cases, deposits are already present in the prostate and seminal vesicles, but experience shows that in the great majority these improve or disappear after epididymectomy or orchidectomy, an observation which is of ætiological interest and supports the theory that the primary lesion is in the epididymis. Barney* in 113 cases found prostatic and vesicular lesions cleared up in over 60 per cent. of cases. The operation is only one part of the treatment and it should be followed by long courses of general therapeutic measures, including tuberculin administration, dieting and heliotherapy.

Technique.—Since the vas must be removed as far as the internal abdominal ring, an inguinal incision is necessary, but in some cases, where there are abscesses or sinuses in the scrotum, removal of the epididymis must be carried out through the scrotum to avoid infection of the inguinal region.

(1) **In uncomplicated cases** an incision is made over the inguinal canal extending from ½ inch lateral to the internal abdominal ring and carried down to the spine of the pubis ; the external oblique is split in the direction of its fibres and the inguinal canal thus laid open and the cord defined. A finger is then passed down into the scrotum, separating the testicle in the tunica vaginalis from the scrotal integuments and delivering the whole through the inguinal incision. The vas is separated from the other constituents of the cord up to the internal abdominal ring, clamped, ligatured, divided and its cut end cauterized with pure carbolic. The tunica vaginalis is laid open and the epididymis separated from the body wherever the plane of cleavage is best defined ; tracing the vas down from above may help in separating the globus major. The greatest care must be exercised to prevent damage to the spermatic artery, as the future existence of the corpus testis depends upon its preservation. Bleeding points are picked up and ligatured and the testicle is replaced in the scrotum. The inguinal canal is repaired by suturing the external oblique fibres and, if necessary, the conjoined tendon, to Poupart's ligament if there appears to be undue laxity. Dependent drainage in the scrotum is established in every case to guard against hæmatoma.

(2) **Where abscesses or sinuses are present in the scrotum.**—To prevent infection of the inguinal incision it is better to perform the operation in two sections : (*a*) Through an inguinal incision the vas is defined and separated, as in the last operation, as far down as the incision will allow, and the cauterized end is surrounded with gauze while the wound

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* Cabot : *Mod. Urol.*, 1936.

is being stitched in all except its lowest part where the cut vas is lying outside the skin incision. The wound is covered with protective gauze to avoid soiling during the second stage. (*b*) Scrotal removal of the epididymis. Sinuses or suppurating areas are surrounded by elliptical incisions which are deepened until the tunica vaginalis is exposed. The latter is carefully separated from the scrotum, endeavouring to avoid opening up septic collections. The whole mass is delivered with attached skin outside the scrotum, and the tunica vaginalis is entered. There may be considerable difficulty in separating the epididymis ; this step will be rendered easier by defining and separating the vas as it lies in the lowest part of the cord, then tracing it into the epididymis, where the plane of cleavage will be shown. In the separation of the epididymis it may be found that tuberculous foci are invading the body ; the degree of invasion must decide whether the testicle should be sacrificed. The vas is separated up to the point where traction on the epididymis will draw the higher section of the vas, already freed in the inguinal stage of the operation, down into the scrotum, when the whole can be removed. The scrotal skin is loosely drawn together by interrupted sutures, ample room being left for drainage.

DIVISION AND LIGATURE OF THE VAS DEFERENS

This is performed as part of the operation of epididymectomy, orchidectomy and seminal vesiculectomy, but it is sometimes carried out independently with the object of checking the spread of infection from the deep urethra, seminal vesicles and prostate, by the path of the vas or its lymphatics, to the epididymis and testicle. It is then a means of preventing epididymo-orchitis where deep-seated infection already exists, or as a prophylactic measure, where it may be anticipated as a complication after endoscopic resection or other operations upon the prostate.

In genital tuberculosis division and ligature of the opposite vas are adopted as supplemental to epididymectomy or orchidectomy in unilateral disease by those who hold that a focus in the prostate or vesicle is responsible for involvement of the epididymis or body of the testicle. There appears to be no justification for claims formerly made that vas ligature influences prostatic development or controls hormonal balance in such a way as to induce rejuvenation.

Technique.—Introduction of 1 per cent. novocain into the skin and substance of the cord procures adequate local anæsthesia. The vas, projected under the skin by digital counter pressure, is under-pinned with a curved triangular needle, exposed, freed, and delivered, cleared of its coverings to avoid inclusion of the spermatic artery and grasped with two pairs of artery forceps. (Fig. 1051.) It is divided between the forceps and the ends are ligatured.

REPAIR OF THE VAS DEFERENS

The vas may be accidentally divided in the course of an operation for hernia, varicocele or hydrocele or it may be torn in accidents and it has been maliciously divided by jealous women. When the injury is recent, the usual technique is adaptation of the ends, previously bevelled to offer wider surfaces for union, and suture with interrupted 6/0 catgut, introduced on round atraumatic needles. In long-standing injuries the ends of the vas are retracted and obliterated ; they must be found and the extremities pared down until the lumens are exposed.

In securing accurate apposition and for preservation of the lumen it is useful to have some form of internal splint. This may be temporary, where a fine needle is entered into both cut ends and removed at the completion of the operation by grasping the pointed end which is made to pierce the vas wall. A splint of catgut or silkworm gut may be allowed to remain, the former until it absorbs, the latter for a few days. Where catgut is used, a two-inch length of 000 is threaded at each end on fine needles. These are passed eye-end into the vas openings, unthread themselves and leave the catgut *in situ* as they are withdrawn. An easier method is to use fine silkworm gut ; the needle carrying it is passed eye-end into one end of the vas and unthreaded within the vas by pushing in a greater length of needle than the length of silkworm gut projecting beyond the eye. The needle is rethreaded and passed point-end first up the other open end of the vas ; it transfixes the wall one inch up. The end will be attached to the skin surface ready for removal on the 4th day.

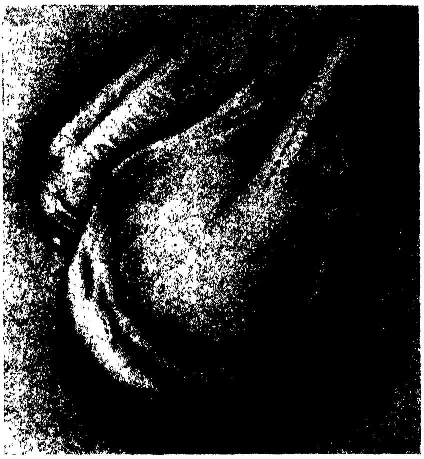

Fig. 1051.—**Exposure of the vas deferens.** The vas is projected under the skin of the side of the scrotum by the finger and fixed by under-pinning with a curved cutting edge needle. The dotted line represents the line of the incision.

Results.—There is evidence that the functional continuity of the vas can be restored by this operation.*

INJECTION OF THE VAS DEFERENS

Although for the most part used as a therapeutic operation with which the name of Belfield is associated, this is frequently employed to-day for radiographic demonstration of the interior of the seminal vesicles (vesiculography). Belfield's operation† has been mainly employed to overcome chronic gonorrhœal seminal vesiculitis clinically responsible for relapsing epididymitis, persistent urethral discharge and iritis.

Technique.—The vas is delivered through a 1-inch scrotal incision, and cleared thoroughly of its coverings, so that a neat incision into its lumen can be made. It is better to open in the long axis than by a transverse incision, as the latter is almost certain to cause a permanent block. An antiseptic (about 5 c.c. of 10 per cent. argyrol is generally used) is introduced through a blunted hypodermic needle. Any excess of injection will escape into the urethra after it has overflowed from the vesicle. I like to have an assistant observing the ejaculatory duct through a posterior urethroscope to check the patency of the vas and as a safeguard against injecting too large a quantity. If it is considered desirable to give repeated injections, the opening into the vas may be kept patent either with a silkworm-gut suture placed in its lumen after each treatment or by a retained cannula* ; otherwise the incision is closed by a 6/0 catgut suture.

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* Freiberg and Lepsky, *Journ. Urol.*, 1939, xli., 934.
† *Journ. Amer. Med. Assoc.*, 1913, lxi, 1867.

Vesiculography

The technique of injection is similar. Lipiodol is the opaque medium generally used.

Anastomosis of the Vas Deferens to the Rete Testis

This operation is performed for sterility resulting from an epididymitis which has caused permanent obstruction to the escape of spermatozoa from the testicle. Before it is undertaken, it is desirable to ascertain (*a*) that the vas is patent at its urethral end, and (*b*) that spermatogenesis is active in the testicle. The former may be proved by exposing the vas as in the operation for ligature, injecting a dye, e.g., methylene-blue, and observing its escape from the urethra ; the latter, by puncturing the testicle with a large-bore exploring needle and examining the material withdrawn microscopically for living spermatozoa,

The anastomosis will be rendered more simple if combined with a partial epididymectomy. The vas is divided opposite the globus minor and split for ½ in. The open end is then laid upon the rete testis, which should be scarified if the previous epididymectomy has not sufficiently laid open the substance of the organ. Interrupted fine catgut sutures passed between the edge of the split vas and the tunica albuginea of the testicle will preserve contact, and the union may be reinforced by suturing the scrotal connective tissues carefully around the anastomosis.

Martin† has described the operation of epididymo-vasotomy, in which the vas is anastomosed to the globus major where fibrosis of the globus minor is the obstructing element. His method bears so close a resemblance to the description given above that no detailed account is necessary. Very fine silver wire is used to unite the vas to the epididymis. Mobile spermatozoa have been found in the seminal fluid after this operation.

Vasectomy

A part or the whole length of the vas deferens may require removal. A short length may be excised in the scrotum to procure sterility. Mere division has been followed by a natural re-union with canalization in

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* Kidd, *Lancet*, Aug. 1923, ii, 213.

† *Penns. Med. Bull.* March, 1902 xv 2 ; *Therap. Gaz.*, Dec. 15, 1909, xxv, 837.

human beings and in animal experiments. To render this impossible, a short segment is resected, or the duct is divided, followed by lateral suture of the terminal half inch of the divided ends.

In castration for trauma, vascular derangements, inflammations and new growths, as much of the vas is removed with the testicle or epididymis as the primary lesion demands. In tuberculous disease the vas is always taken as far as the internal abdominal ring. H. H. Young* regards this as too conservative and describes the removal of the whole length as far as its ampulla through an extraperitoneal abdominal approach. Should excision of the seminal vesicles and the prostate also be considered necessary, these, with the ampullary end of the vas, may be removed by access through an inverted U-shaped perineal incision,[†] which may be combined with the abdominal operation.

OPERATIONS ON THE TESTIS

ORCHIDECTOMY

The indications for orchidectomy are :

(1) Certain cases of undescended and misplaced testicle.
(2) Certain injuries, i.e., severe contusions and gunshot wounds.
(3) Torsion of the cord, producing necrosis of the testicle.
(4) Inflammatory infections—(a) *acute* : B. coli and pyogenic infections ; (*b*) *Chronic* : tuberculous disease, syphilis. B. coli and pyogenic infections.
(5) New growths, whatever their histological structure, as all are malignant or potentially so.

Two varieties of operative removal are practised : (*a*) local, and (*b*) radical.

(*a*) **The local operation** consists of tying off the cord in the inguinal region, either with a ligature which includes all structures *en masse*, or by transfixing with a threaded aneurysm needle and ligaturing in two sections, the ligatures being interlocked to prevent slipping. Where tuberculous or pyogenic infection exists, a strict ritual of toilet of the divided vas, isolation, cauterization and ligation must be faithfully followed. It is usual to divide the vas at the internal ring in tuberculous cases, unless the operator elects to take it as far as the vesicles, or even to include them and the prostate. Statistics do not appear to have proved the value of the radical procedure (see p. 2170).

In malignant disease the problem is complicated. The unsatisfactory results of simple orchidectomy before the introduction of irradiation led to heroic attempts to eradicate the disease *en masse*. Reversion to the local operation is now almost universal, for the radical operation never had a recovery rate justifying its adoption and, further, X-ray treatment has been shown to offer a better prospect of cure than far-reaching operative surgery. Where local removal is put into practice it is sometimes wiser to subject the testicle to a preliminary course of

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....., *Urol.*, 1926, i, 326.

[†] *Arch. Surg.*, 1922, iv, 334.

irradiation lasting for five to six weeks, partly to test the radiosensitivity of the tumour by its alteration in size, and partly to devitalise the active tumour cells, in the hope of lowering the risk of dissemination during operative manipulation. As a further safeguard, division of the cord in the inguinal region with the diathermy knife should be an early step of the operation. Pre- and post-operative irradiation of the lumbar lymphatic field is a very necessary supplement.

(*b*) **The radical operation.**—Chevassu, Bland-Sutton and Morriston Davies were responsible for the pioneer efforts to establish the merits of this operation in the early years of the present century. More recently, Hinman has been the chief contributor to the literature, recording favourable experiences of the operation supplemented by radium and X-ray therapy.

Technique.—The object of this operation is to remove the testicle, the whole cord and the corresponding abdominal lymph nodes *en bloc.* An incision is made from the scrotum upwards over the inguinal canal, thence to a point ½ in. internal to the anterior superior spine, and prolonged upwards to the tip of the 10th rib. The testicle is delivered through the scrotum, and the inguinal canal is thoroughly opened up by splitting the external oblique aponeurosis to enable the whole thickness of the cord with its constituent elements to be freed. The muscles of the abdominal wall are then divided in the line of the rest of the incision, exposing the peritoneum, which is separated without being opened, and thrown upwards and inwards. Care is taken to catch and ligature the very numerous small vessels which are encountered. The vas is ligatured and cut across as it sweeps down into the pelvis. The next stage consists in widely opening up the rest of the wound to gain good access to the retroperitoneal region, thus allowing dissection of the fascia over the psoas and iliacus, with the spermatic vessels and lymphatic glands lying adjacent to the vena cava and aorta as high as the pedicle of the kidney. The primary glands affected are those at the lower end of the chain ; as the disease advances, glands on the opposite side become involved owing to the free intercommunication of lymphatic channels across the mid-line.

The operation is followed by considerable shock and, as admitted by Hinman* in his earliest series, an 11 per cent. operative mortality.

Further considerations.—When undertaking treatment of a testicular tumour its nature, degree of malignancy and radio-sensitivity should theoretically be tested by all available means, for the choice of procedure and the prognosis will be influenced by recognition of the type in question. Biopsy, apart from orchidectomy, is unjustifiable from the risk of dissemination. Reference has been made to the important inference drawn from the reaction to irradiation. The more radiosensitive tumours, which possess a preponderance of embryonal cells, are necessarily the most favourable. These, the seminomata, should be subjected to local orchidectomy after a course of irradiation, the optimum effect of which will have been produced by the sixth week. The more differentiated adult-celled teratoid tumours and, most of all, the chorion-epitheliomata show an ascending grade of radio-resistance, as proved by the therapeutic test of irradiation. In these an early radical operation offers the only hope of prolonging life.

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* *Journ. Amer. Med. Assoc.*, Dec., 1914, lxiii, 2009.

Assistance in the diagnosis, prognosis and choice of treatment, as well as inference on recurrence or metastases is provided by the Ascheim-Zondek biological test which depends upon the presence of prolan A in the urine. This hormone, injected into female mice, produces within a week easily recognizable changes in the uterus and ovaries. In this way biological activity is a measurable quantity and is represented in mouse units. Radio-resistance runs parallel to the number of mouse units; thus the seminomata, the most radio-sensitive tumours, will show only some 500 whereas, at the other end of the scale, the chorion-epitheliomata average 100,000 units. With radiosensitive tumours a single exposure may induce a considerable fall in the prolan excretion; disappearance is regarded as indicative of cure, and re-appearance signifies recurrence or metastasis. It is said that over 90 per cent. of testicular tumours will give a positive Zondek reaction. The majority show a low prolan content, and, being radiosensitive, the prognosis in these, the so-called seminomata, is not unfavourable.

RESULTS OF OPERATIONS FOR TUBERCULOUS DISEASE OF THE EPIDIDYMIS AND TESTICLE

This disease, so often a manifestation of low resistance, is, in consequence, frequently associated with urinary and extra-urinary foci, and has a high mortality whatever treatment be adopted. Genital tuberculosis being, *per se*, non-lethal, operations have little influence upon expectation of life, but a very considerable influence on neighbouring and associated lesions in the genito-urinary apparatus. The effect of epididymectomy in conserving and safeguarding the testicle is proved and, in view of the probability of contra-lateral involvement with, possibly, rapid invasion of the testicle, results have established beyond question that the endocrine function of the primary side involved can be protected by epididymectomy.

Apart from such local effects of a limited operation, more distant influences are observed. Reference has already been made to diminution and even to disappearance of foci in the vesicles and prostate following epididymectomy or orchidectomy (p. 2163). Barney and others, including Lee and Bowes* have found such favourable results; the last found later recurrence of these lesions in 4·9 per cent. of cases who had been subjected to either operation.

An equally important matter for consideration is the relative influence of a conservative operation, epididymectomy or orchidectomy with limited vasectomy, and a radical (*i.e.*, additional) removal, of the whole length of the vas deferens and the vesicles, upon prevention of invasion of the opposite epididymis. Von Bruns[*] after the former found the percentage of contralateral invasion to be as high as 29. More recently, Thomson-Walker was forced to a similar conclusion regarding the incidence of opposite side involvement, this often appearing within a year of operation ; and Lee and Bowes found 38.5 per cent. of such recurrences in 62 cases where the vesicles had already shown signs of involvement at the time of the original operation. Sanford found 20 within from three months to one or more years after 77 cases of epididymo-vasectomy. On the other hand, Horwitz[†] found more favourable results, and V. C. Hunt[‡] only met opposite recurrence in 2 out of 33 cases subjected to epididymectomy, the remainder keeping free for periods up to five years. Lee and Bowes studied the influence of the radical operation in 16 cases in which the vesicles were involved ; they found opposite recurrence in 37·5 per cent. of cases, which closely resembled the incidence of recurrence after the limited operation (*vide supra*).

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* *Brit. Journ. Surg.*, 1934, xxi, 83, 456.

The mortality rate of tuberculous epididymitis was studied by Sanford in an entire series of 156 cases over a period of 20 years ; 72 were known to have died, 42, many of whom were inoperable, died within two years of the onset of epididymitis ; 31 patients who had been subjected to a conservative operation were alive and well one to five years after leaving hospital ; 1 patient was alive two years after the radical operation, and 2 others so treated were not traced.

RESULTS OF OPERATIONS FOR MALIGNANT DISEASE OF THE TESTICLE

Among the reports of earlier writers, where simple castration alone was performed, 30 out of 48 cases showed metastases in the retroperitoneal glands within a year (Kober), Hinman found 81 out of 100 cases were dead within four years[§]. Tanner in 1922 found only 5·5 per cent. of 465 castrated subjects alive four years after operation. With the advent of X-radiation a more optimistic outlook became possible. Dean, in 1929, by the full use of radium and X-rays, either supplementary to operation or independently was able, in the operable cases, to find 13 out of 16 living and well, 4 for more than four years. Of the inoperable class, 8 were living four years after commencement of treatment, 24 for shorter periods.

Cairns[‖] reported no post-operative mortality for the radical operation and 5 out of 19 cases later showed no sign of recurrence. By far the longest series was studied and reported by Hinman ; in 1933[¶] 109 cases showed a 17 per cent. five-year cure, including 4 cases which were found at operation to have pre-aortic metastases. In 1935[**] 10 of his personal 14 cases were living one to ten years after operation ;

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[*] *Centralbl. Chir.* 1901, xxviii (Beilage), 119.

[†] *Journ. Amer. Med. Assoc.*, 1902, xxxviii, 1607.

[‡] *Arch. Surg.*, 1924, viii, 811

[§] *Journ. Amer. Med. Assoc.*, Dec., 1914, lxiii, 2009.

[‖] *Lancet*, 1926, i, 845.

[¶] *Surg. Gyn. Obst.*, Feb., 1933 lvi, 450.

[**] *Journ. Urol.*, July, 1935, xxxiv, 72.

of the survivors between one and fourteen years 4 had been found at operation to have metastases. The tumours in 11 of the 14 cases were radio-resistant mixed-celled teratomata. A case of chorion-epithelioma died of metastases 10 months after operation. These figures justify his more optimistic outlook and support his contention that the radical operation with the aid of radium and X-radiation can claim 80 per cent. of cures.

Gordon-Taylor and Till* have found the results of the radical operation less favourable and confine their treatment to the combination of X-ray therapy and local orchidectomy. Referring to the results of operation where malignancy supervened in 15 personal cases of retained testicle, of which 8 were abdominal and 7 inguinal retentions, Gordon-Taylor states that 3 of the inguinal cases were cured by local operation and X-ray treatment; in the abdominal cases life was very brief whatever treatment was adopted.

OPERATIONS FOR IMPERFECT MIGRATION OF THE TESTICLE

The testicle may be arrested at any point in its normal path of descent (incompletely descended testicle) or drawn aside into an abnormal position (ectopia testis). John Hunter considered that defective structure, deficient function, and failure to reach the scrotum combined to express a state of imperfect development. Degeneration of the spermatogenetic cells, according to Monod, accounted for the sterility of cryptorchids. Environment, especially unsuitable temperature, is believed by Wangensteen and others to account for imperfect development of the extra-scrotal testicle, a theory supported by the animal experiments of Carl Moore.† Up to the age of 10, or even puberty, little if any histological peculiarity can be recognized in the retained gonad; later, the testicle is relatively small, spermatogenetic cells are either degenerate or replaced by sustentacular cells, but interstitial (Leydig) cells are increased in number. Evidence that endocrine balance is at fault is provided by the associated penile and scrotal under-development in a large proportion of double cryptorchids. The problem of the physiological value of the imperfectly descended testicle is not yet fully solved. The endocrine function is held to be little affected and secondary male characteristics are, as a rule, present in double cryptorchids. Spermatogenesis is generally regarded as aborted where the testicles have failed to reach the scrotum naturally by puberty. It is necessary to verify that inguinal testicles are not merely "retractile,' for these are anatomical accidents and need not come within the category of arrested development (*vide infra*). Examples of parentage in double cryptorchids may be thus explained.

Hormone treatment.—Interest has been added to the ætiology of imperfectly descended testicles by the discovery that a hormone of pregnancy (pregnyl) influences development and descent. Extended trials of this substance have shown its limitations and indicate that successes are only to be expected in so-called " movable inguinal " testicles, the very cases which would, in all probability, have descended automatically in course of time, for it must be realised that spontaneous descent of the testicle after puberty is not as uncommon as is generally supposed. Drake,[*] studying late descent in schoolboys, found that 22 testicles arrested before puberty were descended between the 15th and the 17th years. R. E. Smith [†] similarly calls attention to the frequency of descent at, or soon after, puberty, and recommends that biological treatment should be deferred until then.

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* *Brit. Journ. Urol.*, March, 1938, x, 1.
† *Anat. Rec.*, 1932, xxiv, 383.

Spence and Scowen,[‡] analyzing the results of hormone treatment in 66 bilateral and 32 unilateral cryptorchids, regarded this as likely to succeed in the absence of an anatomical hindrance, but considered the universal success in retractile testes no tribute to hormone therapy since all such glands descend without any treatment. Of the " movable inguinal testes " 76 per cent. of the bilateral and 64 per cent. of the unilateral examples responded, but on those which were impalpable or immovable treatment failed. If, therefore, no improvement could be observed after a six-months' trial, an anatomical defect was suspected and operation accordingly advised. Neither undue enlargement of the penis nor degenerative change in the testicles was observed as the result of biological treatment. The dose employed should not be less than 500 rat units given intramuscularly twice a week. Hormone treatment is considered inadvisable below the age of 10 from fear of inducing precocious puberty. No improvement was seen in any case over 18 years of age.

Mimpriss,[§] while carrying out an investigation on the influence of pregnyl, saw that spontaneous descent took place in a high proportion of his untreated controls as the testicles developed in succeeding years. Retention in the controls was of a similar type to that seen when success was attained by hormone therapy. He also made experimental examination of structural alterations within the testicle induced by pregnyl, using immature rats. Where the testicles were descended, an early stimulus to growth was followed by a lag, but no degenerative changes took place. In those testicles in which artificial retention had been produced, the same stimulus and lag were found but, in addition, definite degeneration was found in the tubular epithelium, with intertubular fibrosis.

So far it may be said that hormone therapy has had little more influence upon the surgery of imperfectly-descended testicles than to postpone operation while awaiting a fair trial of pregnyl. Formerly the 8th year was considered to be the most suitable for operation ; now most surgeons prefer to wait until the 10th or 12th, or even until the period of puberty is past, for delay introduces no additional difficulties into the operative technique, development of the testicle is little, if at all, influenced, and function may be discounted. If, however, a hernia is present, giving pain, threatening a weakness of the abdominal wall or showing a tendency to strangulate, operation must be proceeded with at, possibly, a much earlier age. A symptomless hernia is no indication for an operation, indeed it may be an asset through burrowing a track or keeping open a path of descent.

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[*] *Journ. Amer. Med. Assoc.*, 1934, cii, 759.
[†] *Proc. Roy. Soc. Med.*, 1937, xxx, 1827.
[‡] *Lancet*, Oct. 1938, ii, 983.
[§] *Lancet*, March, 1938, i, 533.

Choice of treatment.—Apart from the necessity for operation dictated by a hernia or torsion of the testis, no agreement has been reached and, until prolonged trial and late results of hormone treatment are available, is not to be expected. No doubt imperfect appreciation of the mechanical factors responsible for the abnormality accounts, in part, for the difficulty of making decisions. Denis Browne* has pointed out the laxity of anatomical descriptions, for instance the statement that a testicle palpable in the inguinal region is retained in the inguinal canal. This is impossible, for so soft and attenuated a structure could never be felt through the strong aponeurosis of the external oblique muscle. A palpable and, possibly, visible testicle in the position of the inguinal canal really lies superficial to the aponeurosis in the superficial inguinal pouch, having arrived in this position either by being retracted from the scrotum over the bar of the pubic bone by an over-active cremaster or dartos, or having been prevented from ever reaching the scrotum by an abnormal attachment of Scarpa's fascia to the pubic bone. A testicle in this position is, in fact, ectopic ; a true undescended inguinal testicle, if outside the abdomen, must lie either in the inguinal canal, when it is impalpable, or at or just below the external ring. One of this category lying below the canal is apt to disappear and be lost in the depth of the canal, but can sometimes be made to re-appear on coughing or straining, being aided in its excursions by the hernial sac which invariably accompanies this type ; this is the " elusive " testicle (so-called by Grey Turner). In most cases the true inguinal testicle can only be proved as such and distinguished from the abdominal organ at operation.

By consideration of these points the surgeon is in a better position to differentiate in an old enough child between the testicle which is merely retractile and one which is mechanically held up. The retractile testicle can be coaxed over the pubic bone to the neck of the scrotum or lower ; in time it will descend farther and remain in its scrotal bed, but this can be hastened if development is stimulated by pregnyl. Operation is always necessary where an anatomical barrier exists, as, for example, the attachment of the fascia of Scarpa to the pubic bone, and in many of the true inguinal testicles, although in these, as in elusive testicles, a barrier is hard to prove, so that pregnyl should be given ample trial.

Unilateral cases.—In these, if impalpable or immovable, the tendency will be to operate at an earlier age for, assuming that the other testicle is well developed, an endocrine imbalance cannot be held responsible and, in consequence, the biological treatment should not succeed. Since function can almost certainly be excluded, and in view of the by no means negligible tendency to malignancy especially referred to by Gordon-Taylor and Till,[*] orchidectomy is, on purely surgical grounds, the wisest course; but two scrotal testicles are required in certain services, and for psychological reasons orchidopexy may be desirable. Abdominal replacement is never indicated.

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* *Brit. Med. Journ.*, July 23, 1938, ii, 168.

Bilateral cases.—Grey Turner,[†] regards these as falling into two groups: (*a*) the endocrine-deficient, where the external genitalia are small and ill-developed, and (*b*) those which exhibit only testicular lack of descent, the penis being normally, sometimes abnormally, developed. In the former group artificial endocrine stimulation is the more important, while in the latter operative surgery may supplement or even supplant such treatment. The aim of surgery in all bilateral cases is to implant the testicles in the fundus of the scrotum. If anatomical conditions preclude this, one or both gonads should be abdominally replaced, in the hope that their endocrine function will survive and preserve secondary male characteristics. The risk of future malignancy has to be ignored in this class.

Methods of orchidopexy.—Three types of operation may be performed:

1. Primary placing of the testis into the scrotum of the same side.
2. Primary placing of the testis into the scrotum of the opposite side (Ombredonne's operation).
3. Temporary fixation of the testis to the fascia lata of the thigh as a step towards scrotal implantation (the Keetley-Torek technique).

In the majority of cases of undescended testicle it is possible to elongate attachments sufficiently to allow of emplacement in the scrotal fundus without undue tension. After a long and tedious operation to secure this objective, it is highly disappointing three months later to observe that efforts were in vain and that the testicle has already been drawn to, and even makes contact with, the pubes, The operation which gives the highest percentage of good results, namely that with the aid of temporary thigh fixation, will be described in detail. The less complicated varieties of operation (1 and 2) will be briefly alluded to and easily understood, being simple modifications of the main principles of the early steps of the third.

The thigh fixation method (Keetley-Torek operation).—C. B. Keetley published his original description in the *Lancet.*[‡] Fifteen years later Torek [§] published a full and well-illustrated article on the method, and thus the operation is often associated with his name. Minor modifications were introduced by Wangensteen.[||]

Additional advantages of this operation are that the testicle grows while it is in the thigh; it may even develop an additional blood supply, the cord becomes elongated, and the scrotum, which is often underdeveloped on the affected side, becomes more capacious. Both in this country and in America this appears now to be accepted as the operation of choice.

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[*] *Brit. Journ. Urol.*, March, 1938, x, 1.
[†] *Proc. Roy. Soc. Med.*, 1937, xxx, 1321.
[‡] *The Lancet*, 1894, i, 1008.
[§] *New York Med. Journ.*, 1909, xc, 948.

(i) *Incision, isolation of processus vaginalis and freeing the vas.*—An incision is made over the inguinal canal from the level of the internal to the external abdominal ring. The external oblique fibres are split, divided or separated in this line. The testis, enclosed in the processus vaginalis and covered by internal spermatic and cremasteric layers, can now be identified if it lies in the canal. If it lies outside the external ring, or superficial to the external oblique in the superficial inguinal pouch, it will be readily recognized, but if in none of these positions the peritoneal sac must be opened to allow it to be withdrawn from the abdomen. The coverings are divided and the serous sac (the processus vaginalis) carefully examined, after separating the coverings by gauze dissection. It should be noted if the processus vaginalis is an isolated circumscribed sac, representing a tunica vaginalis, or, as is usually the case, whether it is continuous with the peritoneal cavity, *i.e.*, a congenital hernia, and if its lower end has descended into the scrotum. A fibrous structure, the remains of the gubernaculum, will be seen descending from the tail of the epididymis and the lower part of the tunica vaginalis into the scrotal pocket in those cases where the processus vaginalis ends abruptly in the inguinal region ; division of the gubernaculum will easily permit delivery of the testicle with the tunic, but care must be taken to avoid injury to the vas, which may be looped below the tail of the epididymis. The processus vaginalis is now opened to allow inspection of the body of the testis and, if the upper end is patent, to see whether it is, indeed, a hernial sac of which the neck has remained unobliterated.

If the processus vaginalis extends into the scrotum and is well developed it is better not to attempt to deliver it from the scrotum. It should be opened and explored and then separated from the structures of the cord towards the internal ring. Close contact and the friability of the serous sac render this a difficult step which may, however, be facilitated by injecting saline solution through a hypodermic syringe beneath the serous sac, bringing about an automatic separation and aiding the isolation, ligature and division of the neck of a hernial sac at the level of the internal ring. The finger is next passed into the internal abdominal ring and peels off the vas from the peritoneum in the depths of the pelvis, thus giving additional length to this structure, this step being aided by gentle traction on the testis. To obtain greater laxity of the spermatic vessels a similar method is adopted, the full length of the finger being passed up in the direction of the course of these vessels, so mobilizing the peritoneum of the iliac fossa with which the vessels are in intimate contact. Having thus released the vas and vessels, greater length may still be obtained by dividing fibrous anchoring bands, but in doing so great care must be exercised to avoid division of the spermatic artery for this accident is invariably followed by atrophy of the testicle in spite of the artery of the vas. Preservation of the main vessel is therefore an important factor aiding operative success. Where an insufficient length of the vas plainly hinders the securing of adequate laxity, the deep epigastric artery may be divided at the internal ring or the internal crus of the internal abdominal ring which overlies the artery divided,* but it is better to take the testicle and cord down through Hesselbach's triangle, so that the cord emerges mesial to this vessel and to the internal crus These methods seldom fail to allow the testicle to descend to an even lower level than necessary. (Fig. 1052.)

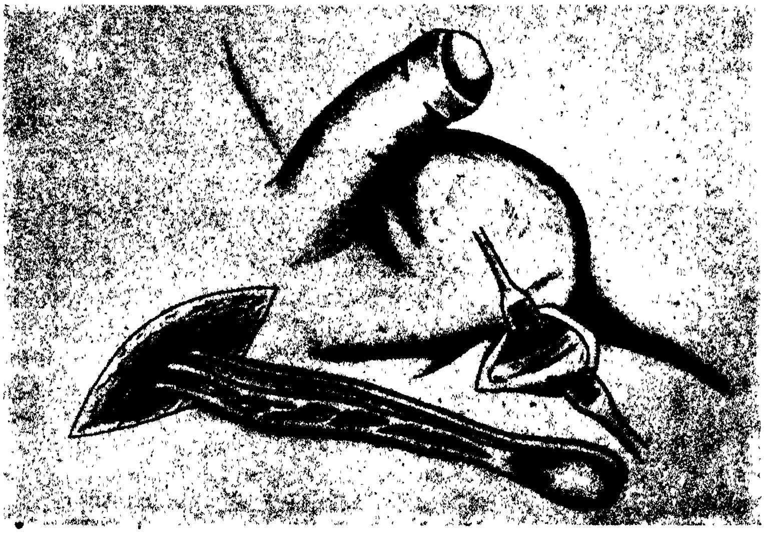

Fig. 1052.—The Keetley-Torek Operation. The testicle has been liberated and adequate length given to the cord and vessels, as described in text. The fascia lata is exposed in the thigh wound.

(ii) *Preparation of the scrotum.*—The scrotum must be prepared to receive the testicle. Where the processus vaginalis was of the scrotal variety, as already described, the index finger passes down within it and is felt to split it as it presses towards and spreads the fundus of the scrotum immediately beneath the skin, at the same time carrying the fundus to that area of the thigh elected for union. A one-inch oblique incision is made through the scrotum, the finger within it serving as a guide and a means of rendering the lax tissue tense.

(iii) *Preparation of the thigh.*—A one-inch incision is made in the area selected, parallel with that in the scrotum. The deep fascia is incised and bleeding arrested. The posterior margins of the thigh and scrotal incisions are sutured with interrupted catgut stitches.

(iv) *Suturing the testicle to the thigh.*—With long artery forceps passed up through the scrotal wound the stump of the gubernaculum

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et, March, 1933, i, 460.

is seized (Fig. 1053) and drawn upon and the testicle is thus brought to the thigh and into contact with its new bed, to which it is fixed by two catgut sutures which pass between the tunica albuginea and the exposed fascia lata. (Fig. 1054.) (Wangensteen prefers to leave the testicle within the scrotum and only attaches the gubernaculum to the fascia lata.)

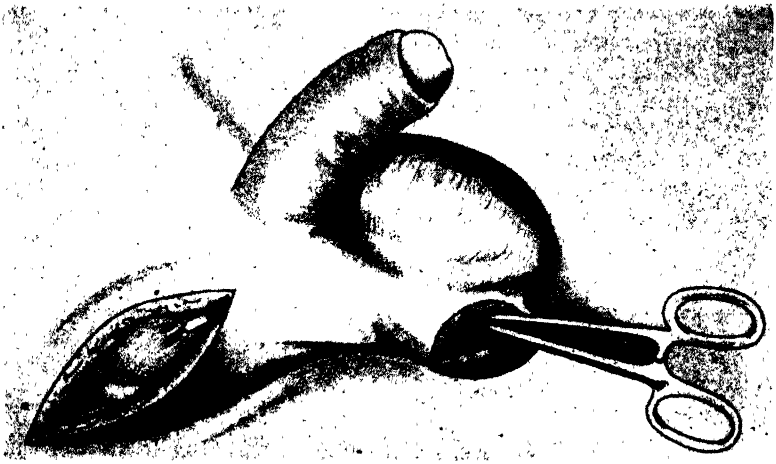

Fig. 1053.—The posterior edges of the scrotal and thigh wounds are sutured. A forceps has grasped the gubernacular stump.

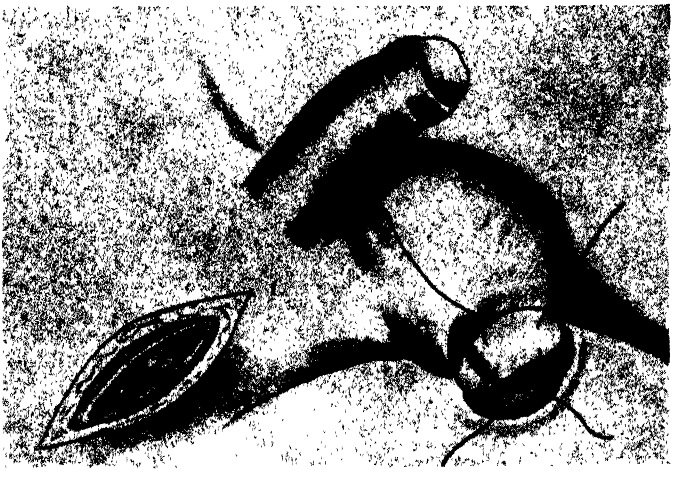

Fig. 1054.—Suturing the testicle to the fascia lata.

(v) *Closure of the wounds.*—The anterior margins of the thigh and scrotal incisions are sutured with interrupted silkworm gut. A gauze strip is inserted between the scrotum and the thigh above the area of the union. The inguinal incision is closed in layers. (Fig. 1055.) If there is much tension on the cord the thigh is kept flexed for two or three days. The child is allowed up at the end of a week and returns to normal life for from three to six months, depending upon the ease with which the testicle could be brought down.

Simultaneous emplacement in bilateral cases is never performed. The second testicle is fixed at the same time as the second stage of the first operation, *i.e.*, when the scrotal bridge is separated.

(vi) *Separation of the scrotal bridge.*— At the selected time, usually three to six months after the first operation, the union is incised circumferentially, the testis is separated and buried in the scrotum, which is sutured over it and the thigh wound is closed.

Fig. 1055.—The wounds are sutured. A gauze dressing occupies the space between the thigh and scrotum.

(*Figs.* 1052-1055 *are reproduced by permission of Mr. Paul Torek, modified from illustrations in " Annals of Surgery."*)

Alternative methods of orchidopexy.—(1) Primary placing and fixing the testicle into the same side of the scrotum. All the preliminary steps are as described. A mattress silkworm-gut suture takes a firm hold of the tunica albuginea and the ends, threaded to long straight needles, transfix the scrotal fundus and then may be attached to the skin of the scrotum or inner side of the thigh, tied around a gauze roll or rubber tube, or to an apparatus such as the Cheyne's cage. The cord may be surrounded by a loose purse-string suture applied to the inner aspect of the scrotal integuments, as described by Bevan, as an additional means of preventing ascent of the testicle.

(2) *Ombredonne's method.**—Again, the preliminary steps are the same. A vertical incision is made through the skin of the anterior

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* *Presse Med.*, 1910 xviii 745.

aspect of the scrotum immediately to the opposite side of the median raphé. The index finger is passed into the scrotum from the groin wound and is made to present at the scrotal wound. By deepening the scrotal incision, integuments, fascia and septum will in turn be divided, the septal division being about half-an-inch in length. Artery forceps are passed from the scrotal to the groin incision, the fibrous structures at the tail of the epididymis are grasped and the testicle is thus brought to the opposite scrotal pocket. If the septal hole appears too lax it can be reduced by one or two sutures.

Abdominal replacement.—This operation is carried out in some cases of bilateral retained testicles in the hope of preserving the internal secretory function when shortness of their attachments will not permit scrotal implantation. The whole length of the inguinal canal is opened, giving thorough exposure of the internal ring. The index finger is passed through the ring into the cellular tissue of the iliac fossa and a bed is prepared in which the testicle is placed. The inguinal canal is then closed by suturing the conjoined tendon to Poupart's ligament and uniting the edges of the external oblique aponeurosis.

Results of orchidopexy.—Broca[*] was one of the first to study results in a series of cases. In 31 (40 per cent.) the testicle was normal in character and position at the end of the first year ; in 35 (44 per cent.) the testicle was normal but the gland had risen to the external ring ; in 13 (16 per cent.) the testicle was atrophied. Tyrrell Grey[†], adopting the method of Collier, *i.e.*, procuring greater length of the spermatic vessels by mobilization of the peritoneum adjacent to the internal abdominal ring, reported a short series of results (31 operations) collected up to a period of ten years after operation. These are given as perfect in 66 per cent., fair in 10 per cent., poor in 16 per cent., and in 10 per cent. atrophy followed. Perfection is defined according to position, size, consistence, relationship to the epididymis, the elements of the cord, and testicular sensation. Burdick and Coley[‡] found 50 per cent. of successes in 573 subjects of the Bevan operation. A later observation by them[§] reviewing the results of the Torek technique, showed strikingly better figures, for of 137 cases 120 successes (90 per cent.) were recorded, and Walters,[‖] reporting upon 100 cases in which the Torek principle had also been adopted in the preceding five years, found the results had been uniformly successful, even though several intra-abdominal testes were included. In only three cases was orchidectomy necessary.

Anatomical perfection thus appears a reasonable expectation, but the physiological problem remains unsolved, assuming that the paucity of evidence of fertility is a criterion. Spermatogenesis and proved paternity are difficult matters to investigate, especially as the subjects of testicular defects show an inherent and not unnatural reticence. McCollum,* however, reviewed a series of 89 cases, among which 15 bilateral cryptorchids had been subjected to orchidopexy. Six of these had begotten children, but it was not possible to confirm potential parentage by sperm counts. Of the remainder, some showed an adequate spermatozoa content but there was no evidence of parentage, while others revealed apparently well-developed testes, but aspermia. The late results of the endocrine treatment will be watched with interest.

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[*] *Gaz. Hebdom. Med. Chir.* 1899, *n.s.* iv, 289.
[†] *Brit. Journ. Surg.*, April, 1930, xvii, 68, 623.
[‡] *Ann. Surg.*, 1926, lxxxiv, 867.
[§] *Ann. Surg.*, 1933, xlviii, 495.
[‖] Mayo Clinic Reports, 1932, vii, 245.

For assistance in provision of material to illustrate the chapters upon the kidney and ureter, the penis and testicle and the urethra, I am indebted to the *British Journal of Surgery*, the *Annals of Surgery*, the *Lancet* and *Medical Press and Circular*; to *Proceedings of the Royal Society of Medicine*; to Mr. Arthur Edmunds for permission to adapt his drawings and to Mr. Paul Torek those of his father, and finally to Miss Collinson and Mr. Thornton Shiells for the several pathological and operative illustrations they have provided.

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* *Arch. Surg.*, 1934, xxxi, 290.

INDEX

NOTE.—This index supersedes the provisional index printed at the end of Vol. I.

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